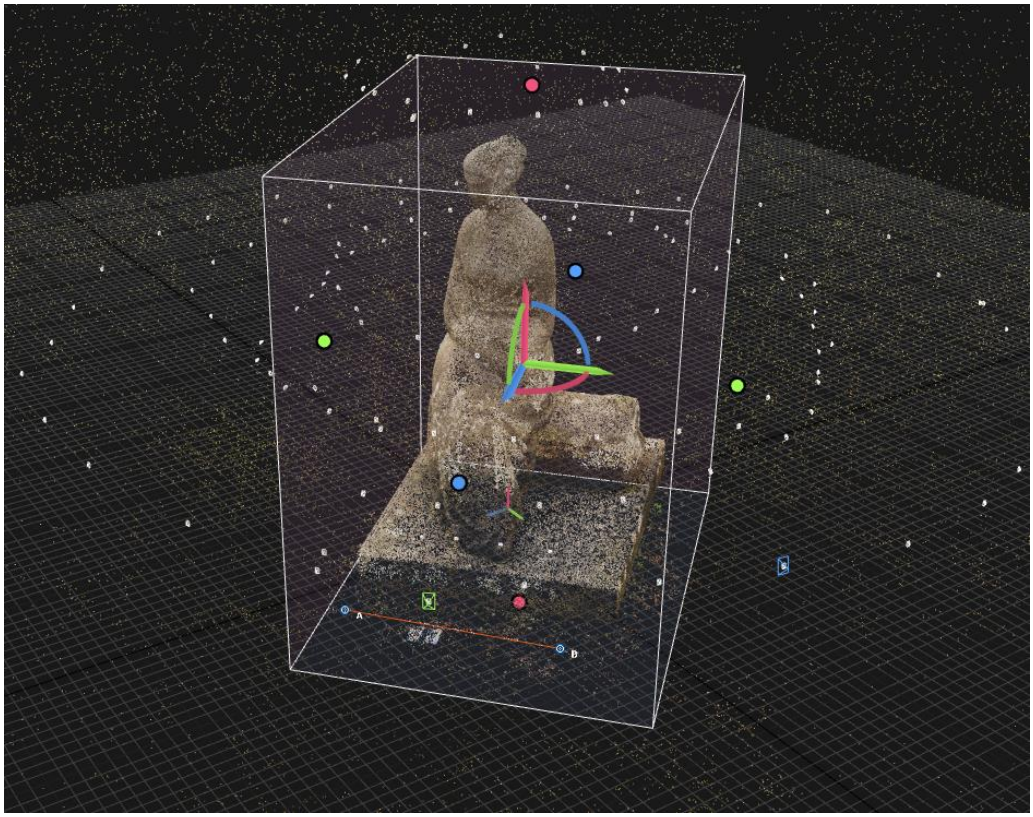
NI4OS EUROPE

OVRET SERVICE

PHOTOGRAMMETRY WORKFLOW FOR ASET CREATION



Overview

1.1 Introduction

a. What is Photogrammetry?

Photogrammetry is the art, science, and technology of obtaining reliable information about physical objects and the environment through processes of recording, measuring, and interpreting photographic images and patterns of recorded radiant electromagnetic energy and other phenomena**.**

Photogrammetry is nearly as old as photography itself. Since its development approximately 150 years ago, photogrammetry has moved from a purely analog, optical–mechanical technique to analytical methods based on computer-aided solution of mathematical algorithms and finally to digital or softcopy photogrammetry based on digital imagery and computer vision, which is devoid of any opto-mechanical hardware.

b. What Photogrammetry is concerned about?

Photogrammetry is primarily concerned with making precise measurements of three-dimensional objects and terrain features from two-dimensional photographs. Applications include the creation of 3d models, the measuring of coordinates; the quantification of distances, heights, areas, and volumes; the preparation of topographic maps; and the generation of digital elevation models and orthophotographs.

Two general types of photogrammetry exist: aerial (with the camera in the air) or using drones and terrestrial (with the camera handheld or on a tripod). Small-format aerial photogrammetry in a way takes place between these two types, combining the aerial vantage point with close object distances and high image detail.

c. How Photogrammetry works?

The basic principle behind all photogrammetric measurements is the geometrical–mathematical reconstruction of the paths of rays from the object to the sensor at the moment of exposure. The most fundamental element therefore is the knowledge of the geometric characteristics of a single photograph.[1]

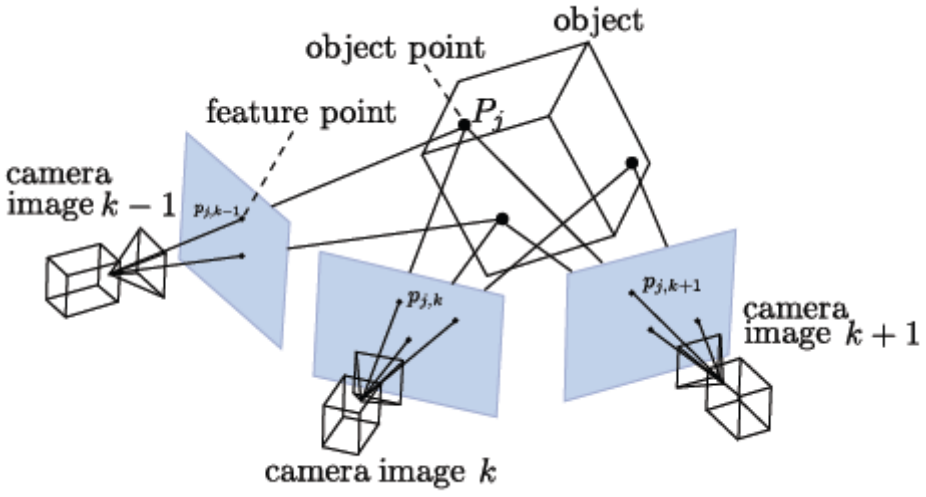


Figure 1 mathematical model of triangulating points
source: https://hackaday.io/project/9792/instructions

[1] https://www.sciencedirect.com/topics/earth-and-planetary-sciences/photogrammetry

1.2 photogrammetry workflow overview

The workflow is divided in two major parts: Capture and processing

- Capturing is about taking photos of an object covering all of it.
- Processing is about generating the mesh and texture data from the photos

a. Capture

The first step is to properly document our object or building from various angles. Also, it is essential to gather extra information for reference, such as scale metrics and color reference chart in order to correctly expose and color balance our photos.

b. Processing

After the proper calibration of photos, they are imported into a reconstruction application, where the reconstruction takes place in order to produce a high resolution 3d mesh. The color contained in the pictures is then transferred to either the mesh's vertex colors (colorize) or to textures used on the surface of the mesh.

Key requirements for photogrammetry[2]

1. The object needs a certain amount of texture. A white paper or a white wall are very difficult to scan because the algorithm can't find points which are recognizable. The same problem occurs if you try to scan a textured surface, but the texture can't be captured due to your camera's resolution. Keep that in mind, that your eyes might see texture, your camera won't capture.
2. Reflection or transparency should be avoided. The algorithm relies on the fact, that the object won't change from picture to picture and object points stay where they are in the real world. If you stand in front of a mirror and move to the side your reflection moves as well. The problem is, that an object point next to the mirror won't move accordingly. The same applies for reflections on cars etc. The reflection moves with the camera movement and therefore should be avoided. The usual approach of painting the surface with a dull color won't work because you won't have enough texture in that area.

In conclusion here is a list of examples that works well for photogrammetry

Good results

- Natural stone
- Trees
- Ground (Streets, paths, etc.)
- Small objects/ artifacts
- Buildings on a larger scale (complete building and not for example a single wall)
- Car interior (depending on the surface, polished surfaces are hard to capture, but the normal plastic surfaces with a bit of roughness work well)

[2] https://hackaday.io/project/9792/instructions

Difficult objects:

- Car exterior (little to no texture, shiny surfaces, glass, reflections.... quite difficult)
- Rooms (large areas like walls without texture)
- Sculls (difficult to capture interior cavities

A good place for references and tutorials can be found on the RealityCapture Site and youtube channel:

- https://support.capturingreality.com/hc/en-us/categories/115000560989-Tutorials
- https://www.youtube.com/playlist?list=PL56jeA0rCS3LWuahdfIFWp1d0WDuEKVqe

And on the sketchfab site:

- https://sketchfab.com/blogs/community/?tag=advanced-photogrammetry&utm_source=sendinblue&utm_campaign=202118_Mozilla_Hubs_Challenge&utm_medium=email

1.3 Equipment

In order to produce high quality results the following equipment is highly recommended:

a. Image capturing methodology[3]

A digital camera with large camera sensor is crucial in order to produce a high-quality photogrammetric reconstruction.

Every camera has an image sensor that acts like a net for catching light, and the more light you catch, the better. Large cameras, like DSLRs, with large image sensors (not necessarily more megapixels) collect more light and yield better results than cameras with small image sensors, like those found in mobile devices.

Large camera sensors are better for photogrammetry, especially in non-sunlight environments, because when you shoot with a high f/stop (small aperture) lens setting that ensures your entire frame is in focus, you'll also have less light reaching your sensor than at lower f/stops (large aperture) settings.

Slowing the shutter speed and increasing the ISO will help your camera utilize the limited light that is available, but together they can only do so much. Slow shutter speeds can cause motion blur if a tripod isn't used, and high ISO setting can cause digital noise appearing as off-color pixels that also hinders photogrammetry software.

Image quality is also impacted by sensor size. When looking at the same scene captured by a smartphone camera and a larger sensor camera, the image quality will look similar or the same if you don't zoom in. But zoom in on both frames, and you'll see how the image produced by the larger sensor has more detail. This additional detail provided by the larger sensor is useful to your photogrammetry software.

Don't limit your attention to the megapixel count, as it alone is not a reliable figure for determining image quality.

[3] https://journalists.org/resources/a-guide-to-photogrammetry-photography/

b. Choosing our equipment[4]

With this short information in mind, we can proceed further in choosing our equipment. Photogrammetry is very forgiving camera-wise — you can get acceptable results with just about any decent camera, including a smartphone or a compact camera. The key word here is 'acceptable.' Your end results won't be a good as if taken with a DSLR and you might forfeit any gains in time with having to take more photos (to compensate for lack of quality) and having to do more image processing in general.

[4] https://medium.com/@EightyLevel/what-camera-should-you-use-for-photogrammetry-3a67864bd4eb

c. Best results

Your best results will come from a camera that allows for:

- manual control
- shoots in Raw
- has an in-camera histogram
- has interchangeable lenses

In short, a mirrorless camera or a DSLR will be your best bet for most projects, yet there will be times when a GoPro or even a drone will come in handy.

1. The full Frame Camera

By default, you'll be taking a large number of photos to get a fully detailed asset, and the better the camera you use, the fewer you'll have to take. A full frame (FX) camera like the Canon 6D or the Nikon D750 will give you the highest quality output in the least amount of photos. (Both of these are often used for photogrammetry.)

2. The DX DSLR or the Mirrorless Camera

Both of these are good options if you're looking for full control at a (somewhat) lower price point. Which one you choose will really come down to what type of camera you're into, but the primary benefit of the mirrorless camera is that it's small and light. As far as cropped-sensor DSLRs are concerned, folks are using a wide variety of DX cameras — none really seem to stand out. In the mirrorless department though, the Sony Alpha a6500 is quite popular in the photogrammetry world. If budget isn't so much of an issue, the Sony A7RII is also a top pick, as is the Olympus OM-D EM-5 Mark II.

3. The *GoPro*

While Go Pros are not ideal as your primary camera for photogrammetry (overly sensitive to high lighting conditions, usually do not have manual controls for ISO and aperture, and often contain blur due to hand-shake), they can play an important role as your backup camera. For example, once you're finished taking the stills with your primary camera, take a quick 4k video of the object with the GoPro, following the same path. In so doing, you'll have a ready-made backup for any areas you might have missed with your main camera or any under sampled or badly reconstructed areas. (Honestly, this simple back up can save you many days of reconstruction correction.) Just make sure that you use a color checker with the video so you can manage the white balance.

Another benefit to bringing a GoPro with you is that it can reach areas difficult for larger cameras and you can get much closer to the object than with larger cameras.

4. The Drone

If you're photographing a very large object (i.e. a building, a cliff, a canyon, etc.) you'll need a drone to get to the upper regions. In this case, it'll be significantly easier to use video. Depending on your software, you should be able to mix the shots taken with the drone with shots taken by hand much closer to the object. The DJI drone Phantom 4 RTF works great in this application

5. The Lens(es)

As always, the better the glass, the better the image. You can buy a stellar camera, but if your lens is only so you won't get stellar results. In most photogrammetry applications you'll want to choose a prime lens with next to no distortion. Not only will this give you the sharpest results, but photogrammetry software will not work with zoom lenses. However, in the field, a zoom is sometimes necessary. Whichever you choose (and it's easy to have one of each), make sure the lens has as little distortion as possible.

6. Rule of thumb[5]

When using a camera with interchangeable lenses, an approximately 25mm focal length (35mm lens equivalent) works well for exterior structure walls and interior spaces, like rooms, and an approximately 50mm focal length (35mm equivalent) works well for objects.

A set of a 40mm prime lens (35mm equivalent) for objects, and a 28mm (35mm equivalent) prime lens for rooms and large structures, like a house. It's best to avoid ultra-wide lenses "below about 22mm (35mm equivalent lens)

Ultra-wide lenses cause distortion, particularly around the edges of the image. Photogrammetry software can successfully remove much of the distortion from photographs captured by ultra-wide-angle lenses, such as on a GoPro, with the exception of around an image's edges.

Zoom lenses work great, for most applications, unless you're doing ultra-high precision work, in which case a prime lens is a must.

7. High detail work

In short, if you're doing an archaeological photogrammetry survey where millimeter precision is needed for reconstructions that will be used for taking measurements, use a prime lens. If you're doing photogrammetry in the field that won't be measured later, use a zoom or prime lens.[6]

8. Popular Photogrammetry Lenses

For full frame Nikons, both the AF-S FX NIKKOR 50mm f/1.8G and the Nikon 20 mm f/2.8D come highly recommended. The Nikon 20 mm f/2.8 AIS works on both FX/DX cameras and outperforms the Nikon 20 mm f/2.8D, but has no autofocus. So, if manual focus is your thing, his is probably the best affordable prime lens to work with. As far as DX-only lenses go, the 40mm f/2.8 "Micro" comes highly recommended. (It's often used for reproduction jobs.) If you want stellar edge-to-edge sharpness and you're shooting smaller objects, the 105mm 2.8 Macro is a good option, depending on the amount of working space you need.

For a full-frame Canon, the Canon 20 mm f/2.8 has superb performance. For cropped-sensor, the EF-S 10–22mm and EF-S 10–18 IS STM comes highly recommended. The Sigma 18–35mm f/1.8 DC HSM Art Lens is also a favorite. Standard all-purpose prime lenses like the Sigma 85mm and 50mm 1.4 Artlenses also work great.

9. Other Considerations

When you're out shopping for a camera, keep these qualities in mind:

- Able to shoot in Raw

[5] https://journalists.org/resources/a-guide-to-photogrammetry-photography/
[6] https://www.tandfonline.com/doi/abs/10.1080/00934690.2017.1338513?journalCode=yjfa20

- Has a fairly high frames-per-second ability (in Raw)
- Long battery life (remember, you'll be taking lots of photos)
- Exceptional low noise performance with a native ISO of 100 or lower
- Will this camera be dedicated to photogrammetry or will you be using it for other applications?

In the end, the main considerations will obviously be your project requirements and your budget.

1. Color checker passport photo (X-rite)[7]

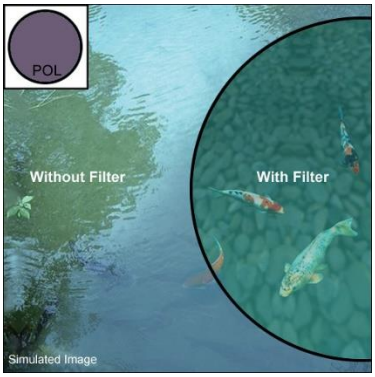
The color checker should be use at each capture to white balance the photos and keep color consistency between photoshoots. For example, between day and evening to avoid shadows on a building. Key advantages in using it are:

- Gray Balance Target to set exposure with an in-camera or handheld meter.
- White Balance Target to create custom in-camera white balance for a consistent white point across a set of images with no need to correct each individual image later.
- Classic Target, the industry standard 24-patch color reference target for creating custom camera profiles and for visual color assessments.

[7] https://www.xrite.com/categories/calibration-profiling/colorchecker-classic-family/colorchecker-passport-photo-2

2. HOYA Polarizer filter PRO 1 DIGITAL

Lens polarizer is used to remove reflection when trying to capture diffuse albedo.



d. Markers and photogrammetry targets

Targets and markers are used to create references for failsafe in manual alignment is needed during the reconstruction process and to create reference points for the reconstruction program to reference onto.[8]

In the case of buildings and exterior sites you can use also targets in order to help the program align the images. The typical rule of thumb is that the more targets the higher the quality and lower the miss-measurement of points

[8] http://archive.fabacademy.org/archives/2016/opendot/students/191/week5.html

Pros[9]

- Advocating rigorous metric controls for photogrammetry of heritage sites and architecture.
- Using coded targets on site, an SLR camera can measure precisely to 1 part in 50,000.
- 3D surface reconstruction is enhanced for precisions of 1 part in 8000.
- Photogrammetry can surpass the quality of laser scanning at a fraction the cost.

Cons

- Need to find a good ration between number of targets and extra labor to remove targets from texture
- Need for two types of photography sessions, with targets and without. One set can be used for the creation of the alignment and the 3d model, the second for the texturing

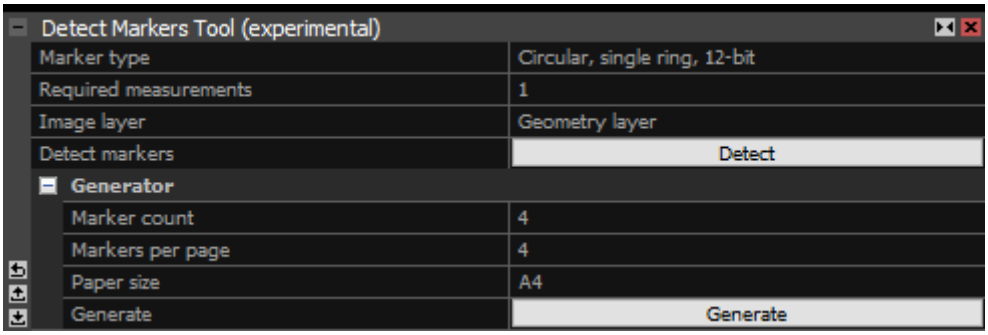
i. Using marker tool in Reality capture[10]

Reality Capture, the program that we will use for the creation of the tutorials, has an automatic detection market creation tool.

This tool enables you to automate the process of placing control points into your images. The tools, helps in the creation of suitable markers and placing them in your scene before shooting and Reality Capture will do the automatic identification.

To use the tool, go to the alignment tab, section Constraints and click the Detect Markers button. The detect Markers tool will show up in the 1ds view.

[9] https://www.sciencedirect.com/science/article/abs/pii/S0305440316000042
[10] https://support.capturingreality.com/hc/en-us/articles/360003869672-How-to-use-Detect-Markers-Tool-experimental-version-

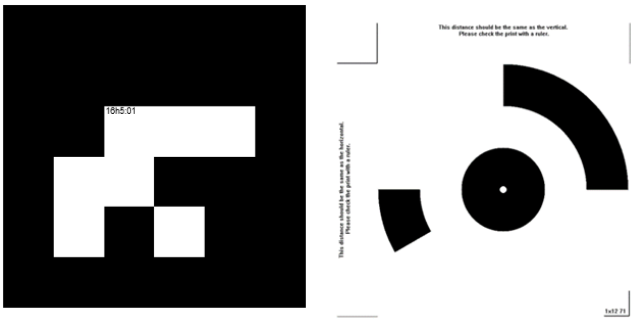


Markers are special high-contrast patterns printed on flat surfaces, whose shape allows them to be precisely located from almost any viewpoint. We generally recommend that the photographed markers are at least 100 pixels wide and it is endorsed for angle between camera marker and vertical shot to be as small as possible for markers to be recognized upon detection.

ii. Generating markers

The built-in markers' generator enables you to generate a desired number of coded markers. Markers are then saved as a PDF file on an A4, A3 or letter size page(s).

- Choose the Marker type you wish to generate.
- In the Markers count, enter the desired number of total different markers to be created.
- In Markers per page choose desired amount of markers to be laid out on one page.
- Click the Generate button and choose a file name and location for the generated file.



An illustration of a Square, April Tag, 16h5 target

An illustration of a single ring, 12-bit circular target

iii. Procedure for the marker detection

- Click the Detect Markers button in the Constraints part of the ALIGNMENT tab.
- Select the Marker type to be detected.
- Select the Required measurements of each marker. Markers detected on a fewer images than the number specified in this setting are discarded. This option effectively filters out markers that are found in fewer than the specified number of images.
- Click on the Detect button to start detecting the markers in images.

In order to detect markers in a subset of input images, select the required images first. TIP: Set Required measurements to a value greater than 1 in order to detect markers robustly and prevent a marker being detected by only one image.

A new control point is created for each marker that has been detected, provided that there is no control point with the exact same name. Any existing control points with matching names are augmented with new measurements but keep all their other properties.

2.0 Capturing

2.1 Photo shooting techniques

The capture process and camera settings[11]

Photogrammetry software needs evenly exposed and deep depth of field images captured using a high f/stop value so the entire frame, or as much of the frame as possible, is in focus.

- Disable in-camera stabilization, as this can hinder the photogrammetry processing algorithms.

Find a balance between f/stop, shutter speed, and ISO settings:

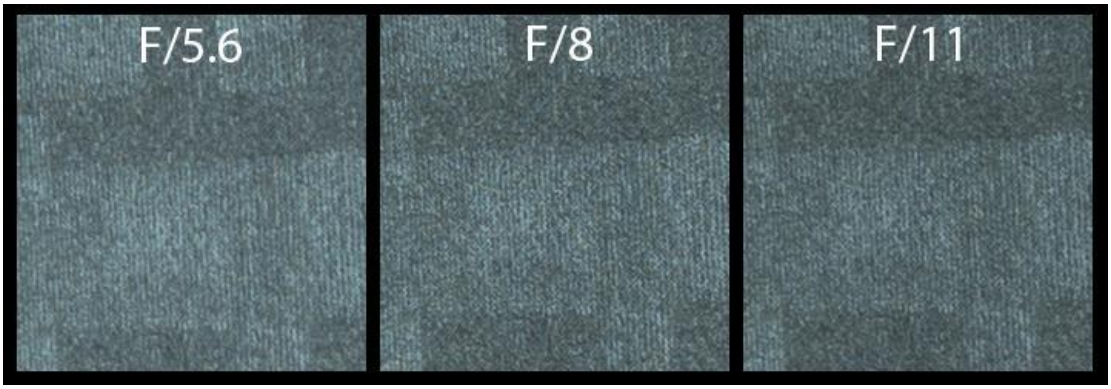
- Use aperture priority or the manual setting, and set your f/stop so the entire frame is in focus. Don't set and forget this setting, as it will change based on your lens and the distance between your camera and your subject matter.
- Ensure your shutter speed is adequate for the lighting conditions and how you will move the camera.
- Handheld: If you're going to capture photos without a tripod, a common practice, set a higher shutter speed of at least 1/200 or faster.
- If you're using a tripod you can set a very slow shutter, ideal for revealing surfaces in darker environments, but severely slows down the capture process, and limiting camera placement and the perspectives you can capture.
- Set your ISO setting so that your photographs of the subject matter are not underexposed. You want to keep the ISO as low as possible so as not to produce digital artifacts in your images. Some trial and error with your camera will indicate where this threshold is. If you're seeing artifacts, noticeable as dark off-color noise in the image, lower the f/stop so that you can achieve an acceptable ISO setting, or shoot with more light.
- Remember: Cameras with larger sensors are more forgiving and create fewer artifacts than cameras with smaller sensors. Cameras with larger sensors also collect more light, lessening your need to increase the ISO. ISO induced artifacts are very bad for photogrammetry because the artifacts obscure the subject matter at the pixel level, decreasing the software's ability to find identifiable points and reducing the overall quality of your 3D reconstruction.

2.2.Debugging[12]

a. Example of correct focus and exposure

The default recommended settings aim to have the sharpest image possible: an aperture of f8 is used with the autofocus set to on as highlighted by this comparison of various aperture:

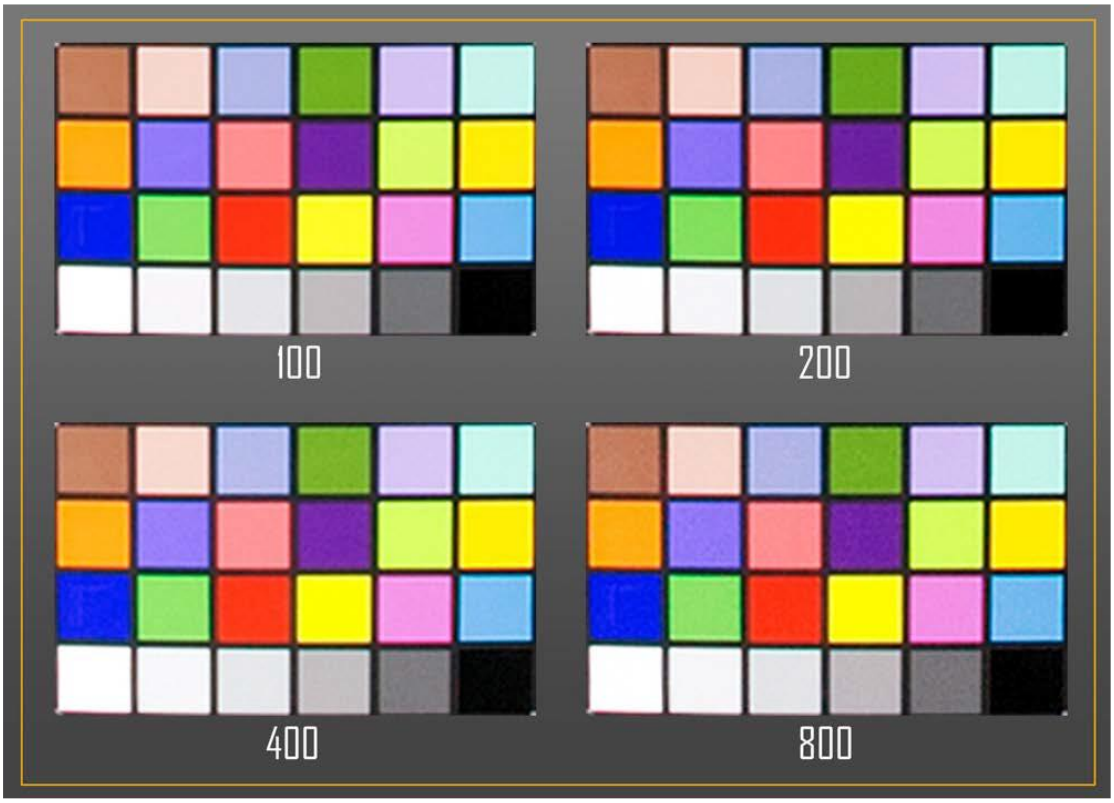
[11] https://journalists.org/resources/a-guide-to-photogrammetry-photography/
[12] Unity photogrammetry guide



If you are shooting outdoors, lighting conditions can vary due to the sun or clouds moving. Therefore, to save time, the use of a tripod is not recommended. Also, don't spend a day to capture a rock! The shutter speed must be at 1/160 or less to accommodate for this fast hand shooting while maintaining a sharp image.

c. Example of ISO settings

ISO should be set to 100-200 or lower to avoid noise especially in darker areas which are not good for the reconstruction software.



In practice, in the case of low lighting conditions, you should first increase the ISO, then the aperture. It can be necessary to adjust the aperture a bit to counterbalance the noise produced by high ISO. With a tripod, it is possible to play with the shutter speed - however using a tripod can add excessive time between shots as described above.

Set the output format to RAW. RAW format has higher accuracy for the reconstruction and allows better white balance in the pictures.

d. Examples of good exposure

Before you start the asset capture, the exposure level must be controlled with the camera histogram to not have clamped pixels on the subject and to have a good exposure range. The example below shows on the left an image where the range is too small to do a reconstruction and many pixels are clamped.

The right image represents a good range to process a reconstruction. The subject is represented in the middle of the histogram.

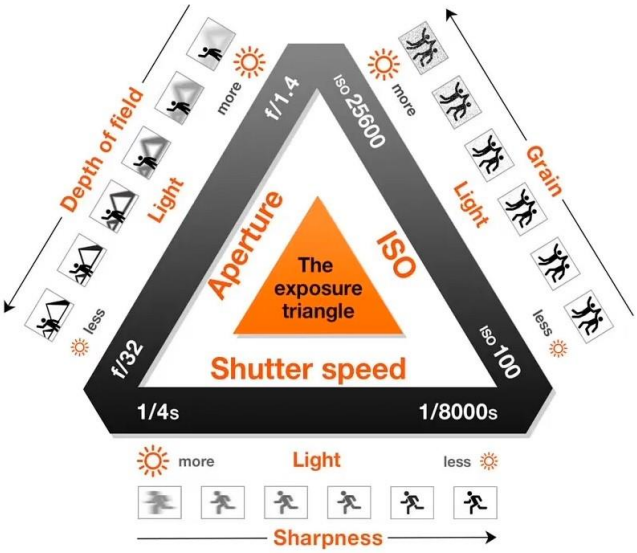
It is important to have an exposure level in the middle of the lighting range because the recommended reconstruction software (Reality Capture) doesn't use the full 14-bit range captured by the camera and photos are converted to 8-bit. The only benefit in using 16-bit photos is in texturing[13]

e. Rule of thumb

- Overcast are the best lighting conditions for outdoor asset photogrammetry
- Or entirely in shadow in order to get all data
- Flat lighting and diffuse lighting with as less contrast as possible with no extreme shadows or highlights in order to create better albedo map (base texture of the 3d model)

[13] https://support.capturingreality.com/hc/en-us/community/posts/360009521580-HDR-workflow-using-16-bit-TIFF

2.3. How to properly setup your camera



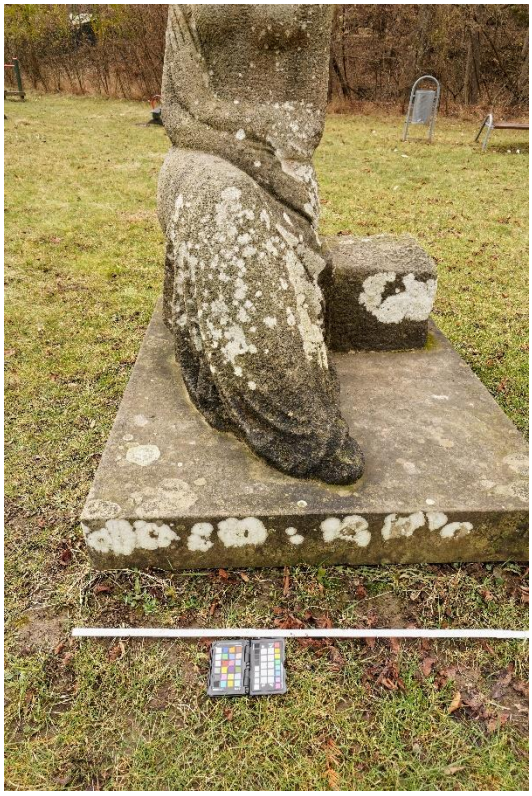
- Based on lighting conditions use the smallest iso possible to get least amount of noise
- Aperture, as a rule of thumb, something between f/9-f/12, depending on lens and lighting conditions. Aperture settings should be taken into consideration in order to keep our main photogrammetry theme in focus.
- Pictures need to be sharp- it is generally advised to use a tripod to make available lower shutter speeds in order to capture crisp image even in conditions with less light. For handheld photogrammetry use shutter speed of above 1/250, with a tripod use any number below that
- Ideal settings are (in ideal conditions)
    - Aperture f/9- f/11
    - Shutter speed 1/250 not applicable since it is advised to use aperture priority mode
    - ISO 100-400 (800 in extreme conditions)

a. Setting the color checker setup and scale metrics[14]

A color checker is used to white balance the photos, but also as a scale metric for the virtual asset.

Knowing the size of reconstructed objects is important as the photogrammetry process loses this information. Find a good location for the color checker. Close enough to the subject, but it shouldn't be shadowed by it. Find a place in the scene that can be easily removed during the process, or digitally paint it out. The color checker should usually be facing the sky.

[14] Unity photogrammetry guide




It is usually important to keep the same ratio between real world and your reconstructed virtual assets, depending on the context of your game. To achieve this, it is required to have a reference object of a known size in the reconstructed mesh that can be used to define the scale.

b. Coverage and overlap

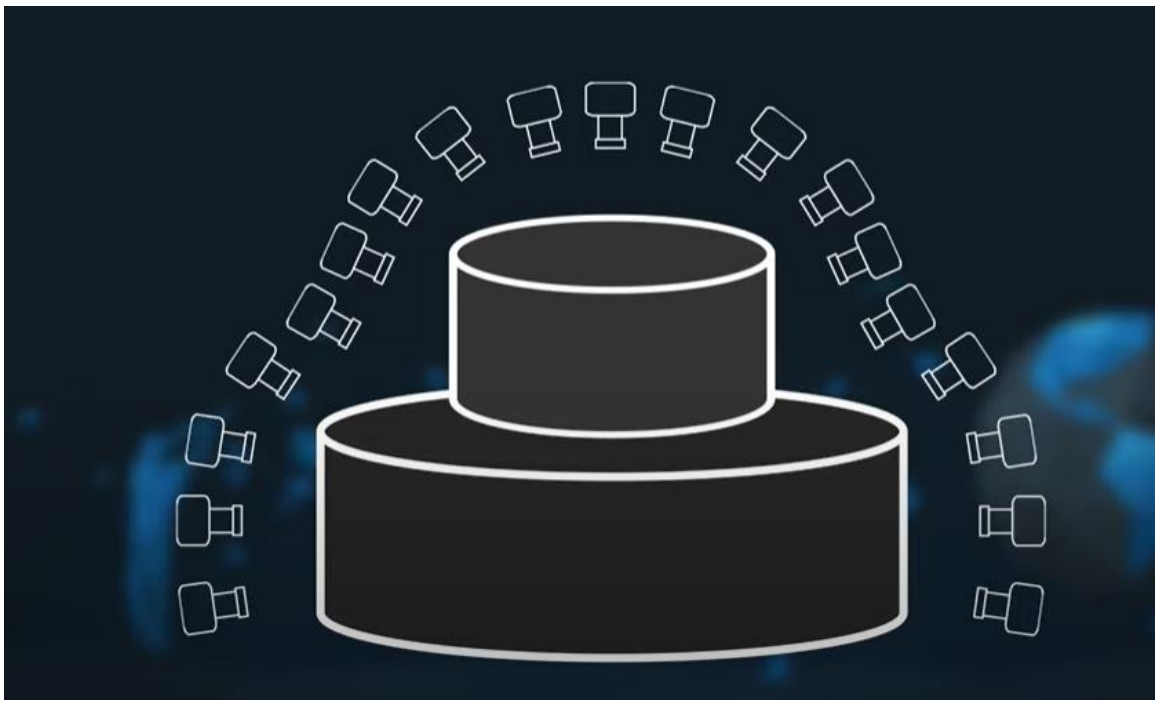
For the purpose of this tutorial we will use an asset provided by Reality Capture software and the following tutorial dataset[15]. In the test case examined, we have been provided a photographed statue in a rural landscape. Fill the frame with your subject, in the image sequence below, with enough overlap from image to image, about 70%-80% on the sides and top and bottom of the frame.

[15] https://www.youtube.com/watch?v=DTJq1Dz0nxY&t=342s
https://www.capturingreality.com/simple-statue-ppi-dataset

c. Shooting strategies

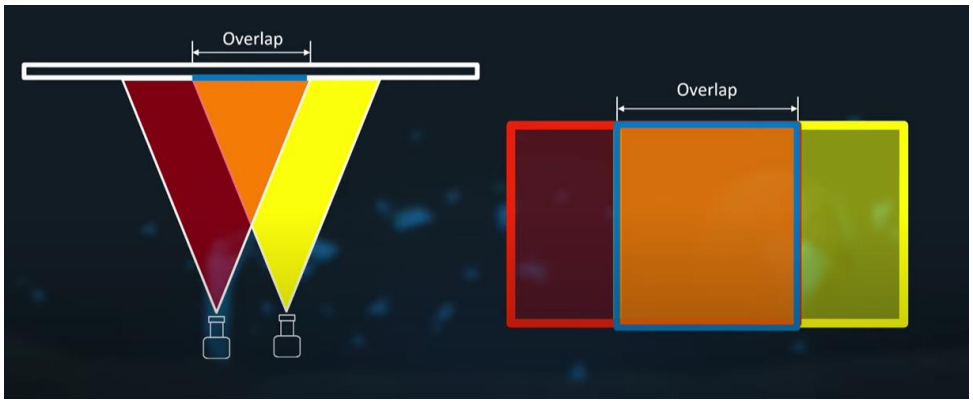
When shooting an object, it is important to have full coverage of it. All parts of the object must be covered by several pictures so the reconstruction software can create groups of similar pixels, so that the final asset doesn't have holes or undersampled areas. The pattern is done by moving around the object and taking many far shots, and some fewer close shots to provide more detail at the reconstruction step. At each horizontal camera location, it is important to also cover the subject vertically.

- Do not limit images count[16]
- Use the highest resolution possible
- Do not lose focus
- Each point should be visible in at least two images
- Shoot a full loop around the object and also loops from several elevations
- Do not change the viewpoint more than 30 degrees
- Follow the shape of the object and keep the same distance throughout (maintain the same level of detail)

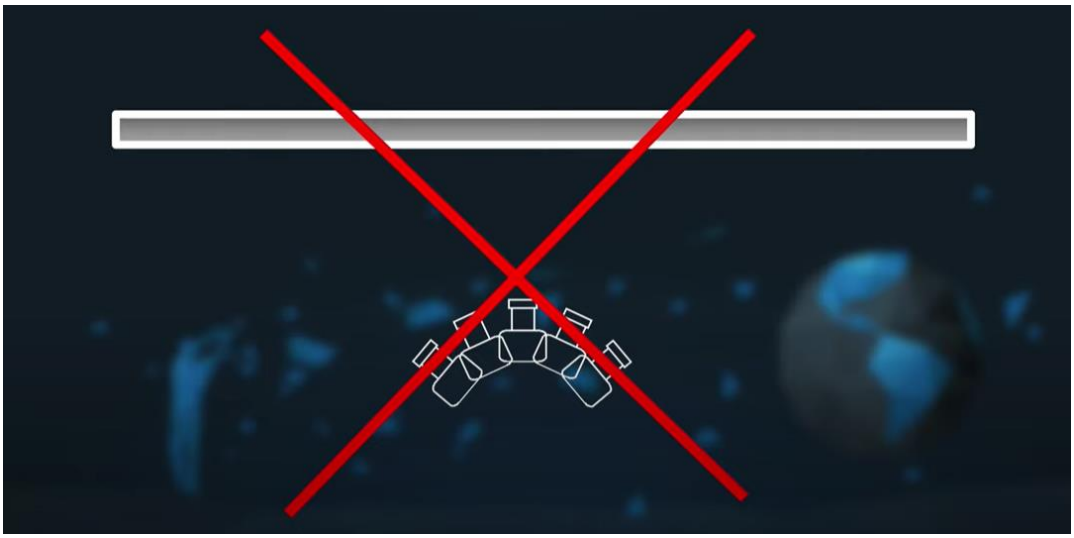


[16] https://www.youtube.com/watch?v=9e_NLp_FaUk&t=2s

- Maintain high overlap between images more than 60% in x, y, z axis



- Do not shoot panoramic pictures



- Avoid object movement (due to wind)
- Avoid transparent and shiny objects if possible (use polarization filter to limit shininess) or use a removable coating on the object to get a set of pictures of the geometry (will be enabled only for geometry in reality capture) and one set with the texture. Due to reflexions, you will capture also reflexions from the environment

- Avoid featureless textures (use markers in this case)
- Keep constant lighting conditions
- Shooting interiors, always shoot opposite walls and do not use panoramas from a single stand point.

Tip!

Additionally, a quick GoPro 4k video of the object can be done by following a similar path. This video can later be used as a backup to extract missing area or in case of undersampled or badly reconstructed area (See Align images). It is fast to do and can save many days of reconstruction correction. The color checker must be on the video to be able to white balance the frames extracted. The Gopro can be used also to cover difficult areas for a camera. For example, interior parts where access id difficult with a bulky camera.

d. Distance and resolution choice

It is also necessary to evaluate the importance of the object to capture. You must define texture budgets for your various assets, and these decisions will drive the choices you make on your Shoot. The shooting distance from the object depends on the size of the object itself, the lens zoom, and the texture budget, timewise and financially. The object should fill most of your images to maximize the reconstruction quality.

When higher resolution is wanted, closer pictures are needed. Note that it can take a long time to cover a big object like a statue or a building with a micro resolution.

In practice, for the capture of a big object like this outdoor statue with a final texture at 4096x4096, the photos should be taken at a distance of between 1 and 2 meters.

e. Shadows

Shadows become a part of your 3D reconstruction. If you set your camera's exposure to properly capture the brighter surface then the darker, surface may reconstruct with holes or digital artifacts due to inadequate lighting where the photogrammetry software fails to identify enough tie points. Late afternoon and evening are a difficult time to shoot photogrammetric images outside because of the fading light and long shadows. When sun-generated shadows are involved, do your photography when the sun is highest in the sky or on an overcast day to minimize shadows, and work as quickly as possible to capture your photoset to minimize shadow movement.

HDR photography is a solution, but only if the camera remains motionless during the multiple exposure capture process[17].

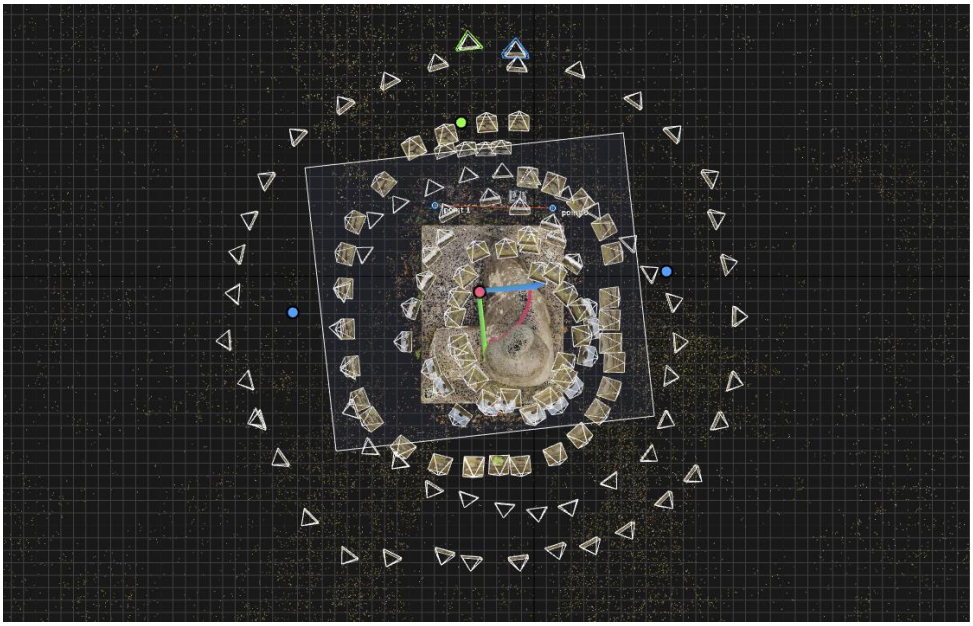
A typical workflow is to slit the photo shooting sessions between times of the day in order to capture all parts of building without shadows. For this process to be effective, we typically choose early morning and late afternoon when the light has similar qualities and intensity. Also, in this type of scenarios, the color checker comes in handy, as it creates a reference point to correct white balance and color temperature between photo sessions.

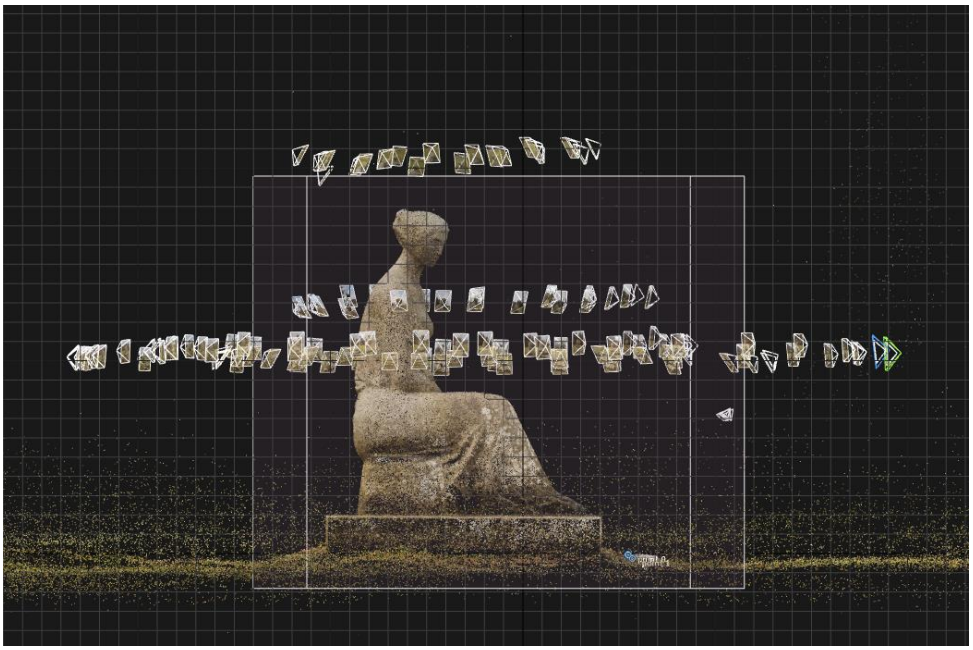
Shooting on an overcast day without rain provides a constant illumination and very soft shadows which makes it easy to remove light from the image later. However, the luminosity is low and the ISO should be raised[18]

f. Capturing a 360 shot of the asset

- Make a test shot with a color chart and adjust fstop shutter speed and iso in order to aim to a good grey approximation
- Shoot in rolls- mid high- low, above and top down
- Detail shots on areas that where obstructed or occluded- sharp corners, under cuts etc
- Maintain distance in all shots to have even resolution allover
- Use a tape measure to capture a reference length for scaling
- Use a color checker to use a reference for color mapping and white/grey balance

[17] https://www.digitaltrends.com/photography/what-is-hdr-photography/
[18] Unity photogrammetry workflow





3.0 Processing- Reality capture workflow

3.1Preprocessing

After capturing a complete set of 360 view images in RAW format we will proceed to preprocessing of the acquired images

a. Raw files and DNG

A raw file contains the "raw" data captured by the digital camera sensor before it has been converted to JPEG or TIFF formats. Cameras that create JPEG or TIFF files process (and in the case of JPEG files, compress) the sensor data. When working with raw files, the file is not compressed or processed in the camera. Instead, software gives the user complete control over the conversion settings. For example, white balance is not applied to the raw file but is stored with the file so the software can default to the originally-intended setting. Other information contained in a DNG file includes standard EXIF metadata (just like in JPEG files), date, time, camera used, and camera settings.

b. Raw files offer the following benefits:

- Smaller files than uncompressed TIFF
- Does not have the artifacts of compressed JPEGs
- Many key camera parameters, such as white balance, can be modified even after the image is captured
- You have complete control over conversion settings rather than letting the camera decide
- Access to 16-bit data for greater detail and fidelity
- Flexibility of converting a single file using multiple conversion settings

c. The Digital Negative (DNG) format

Digital Negative (DNG) is an openly published raw file specification that stores the "raw" pixel data captured by the digital camera sensor before it has been converted to JPEG or TIFF formats, along with standard EXIF metadata, date, time, camera used, and camera settings. This format is freely available for other software and hardware vendors to support.

d. Why convert to the DNG format?[19]

Unlike most manufacturer-specific raw formats, the Digital Negative is an openly published specification that not only is supported by Adobe, but is also freely available for other software and hardware vendors to support. Consequently, it can be a safer file format to use for long-term archival purposes. Archiving your file as a digital negative eliminates worries that the raw file will no longer be readable once the camera format that created it becomes obsolete.

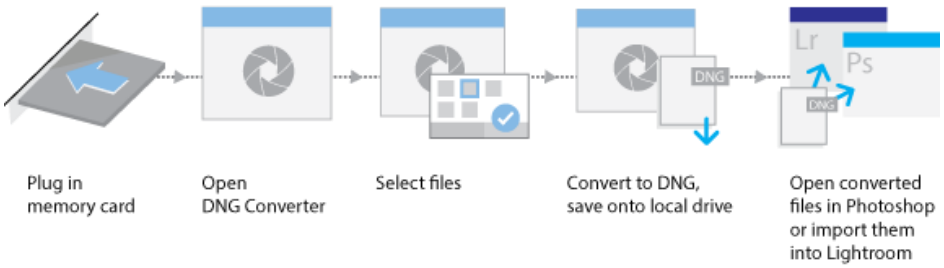
The Digital Negative specification allows for not only all of the pixel information stored in current raw formats, but also for all of the additional, proprietary metadata that many manufacturers include. The Adobe DNG Converter may, in some cases, ignore some of this proprietary metadata, and only include the basic information necessary for creating a high-quality image file. The original raw file, however, can also be embedded in the new DNG format to ensure that proprietary metadata from the manufacturer is not lost.

3.2 Conversion process

a. Convert RAW image files to DNG files[20]

Firstly, we will transform the Raw files to a more manageable file format such as DNG file format using the adobe DNG converter.

The Adobe DNG Converter enables you to easily convert camera-specific raw files from supported cameras to a more universal DNG rawer file. Another benefit of using the DNG Converter is backward compatibility.

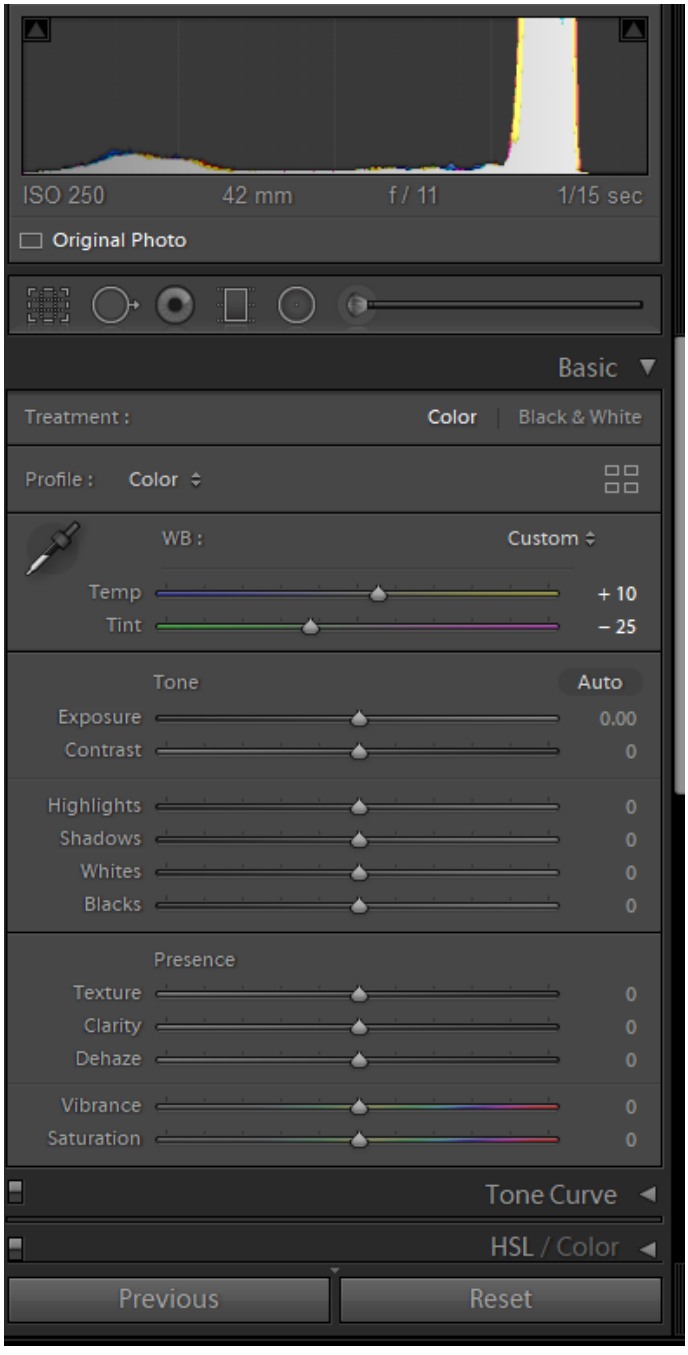


[19] https://www.youtube.com/watch?v=7Ljbo6aL3Jc&feature=emb_title

[20] Source: https://helpx.adobe.com/photoshop/using/adobe-dng-converter.html#Appendix

b. Create color profile

Using colorchecker[21] create color chart based on input DNG raw data and automatically calibrate images to automatically calibrate images. If you have only a color checker and not the application, just white balance on a grey-ish area, that is relatively good between white and darker areas. (60% grey in the case of the color checker). Press on the droplet picker and white balance on a relative area (WB). The same applies for use only with lightroom application, just use the color picker on a neutral area.



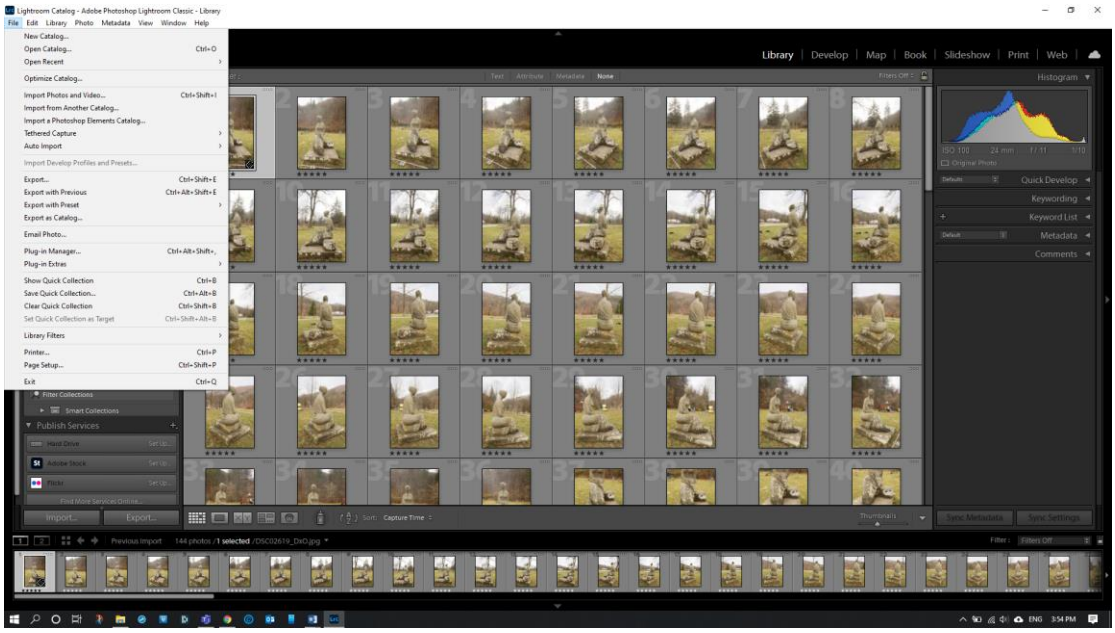
[21] https://xritephoto.com/colorchecker-passport-photo2#

3.3 Preprocessing in lightroom

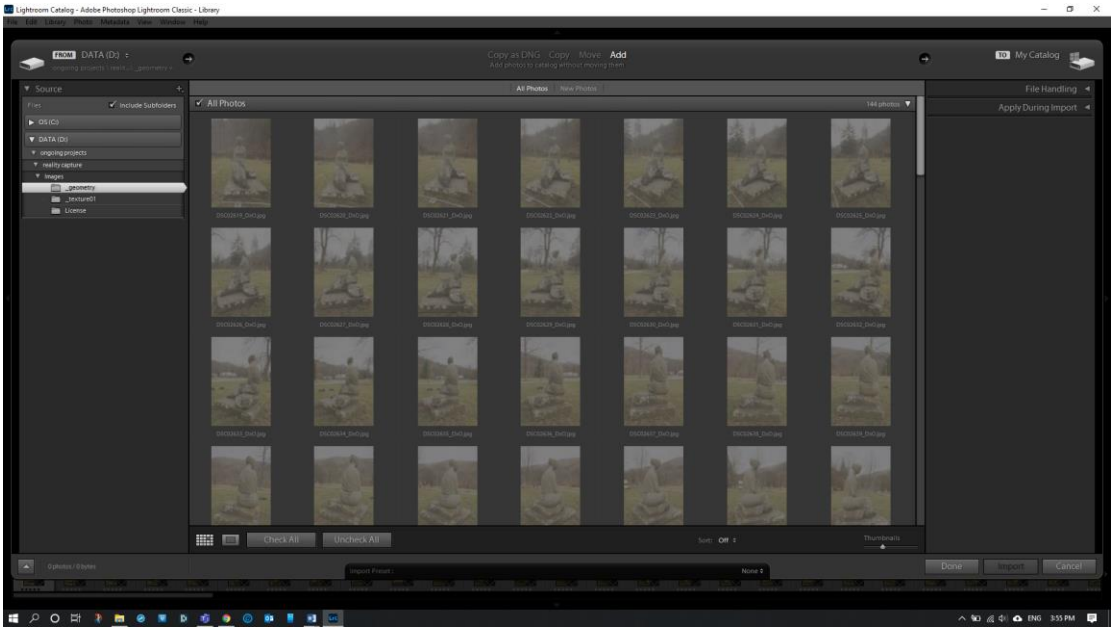
In lightroom we will fix the exposure, lighten the shadowy parts and darken the lighted areas. We also can remove the chromatic aberrations.

Remove the noise and sharpen the image. But be careful as the image CANNOT be distorted in any way.

Fixing the lens distortions is STRICTLY PROHIBITED! Un-distortions in image-processing tools is not photogrammetry correct.

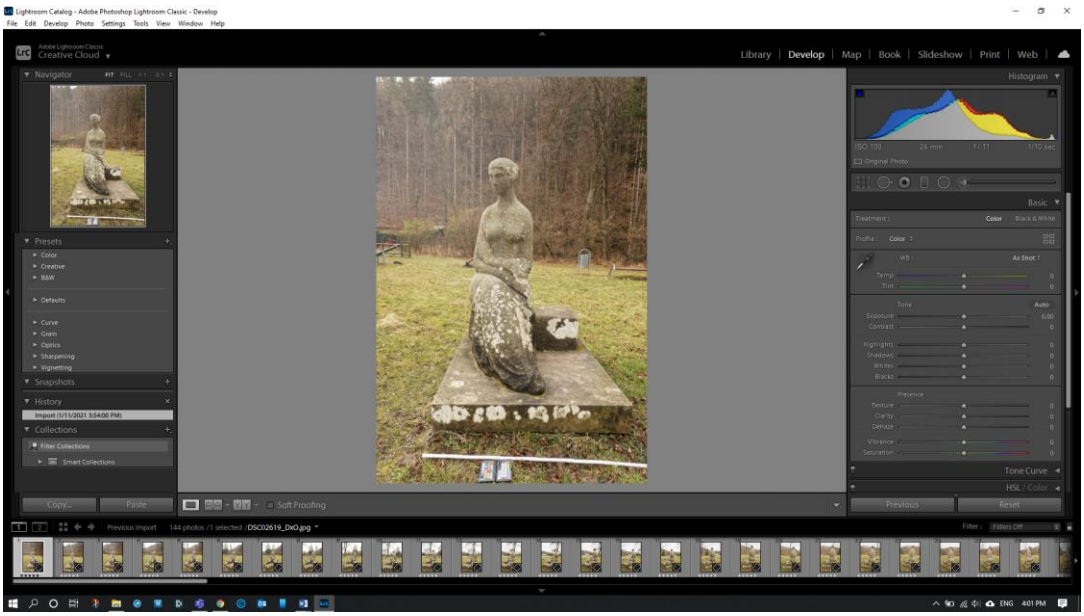


1. Go to file and press import

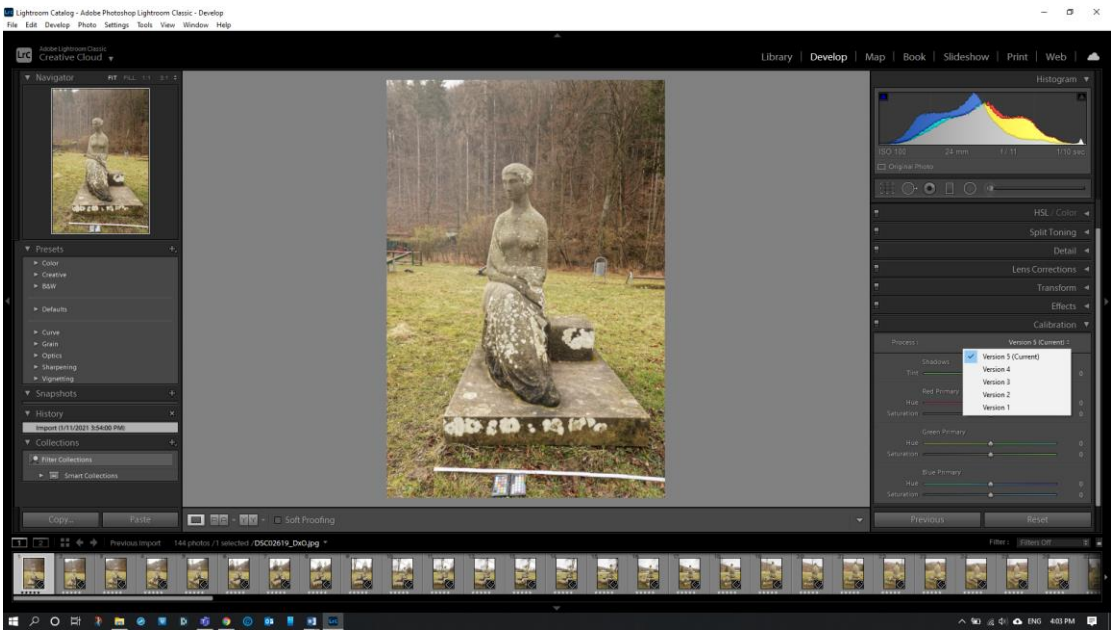


2. Click check all and press import

3. After you have imported and created this new catalogue, click on an image that characterized color and contrast for the most part of this photo session and press develop on the top right.

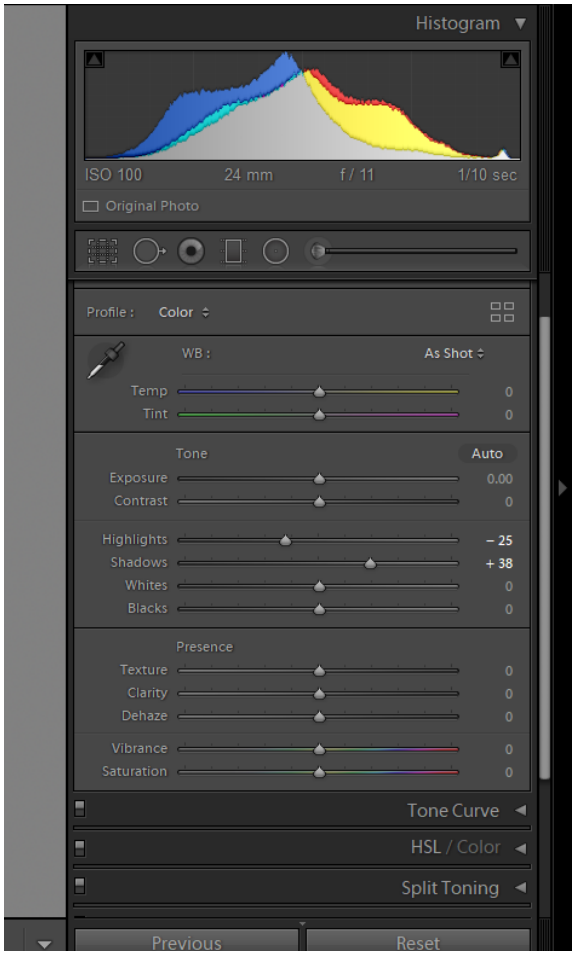


4. Press the “basic” panel to minimize the tab and go to the calibration tab.
5. Go to the process and select the color profile we created from color checker in order to apply the color corrections based on the color passport (see linked video on how to create the color profile with the color checker passport application)



a. Shadows and highlights correction

a. Select a picture that highlights best the overall lighting solution for the space to be modeled
b. Remove excess shadows (move slider to the right)
c. Remove excess highlights (move slider to the left)

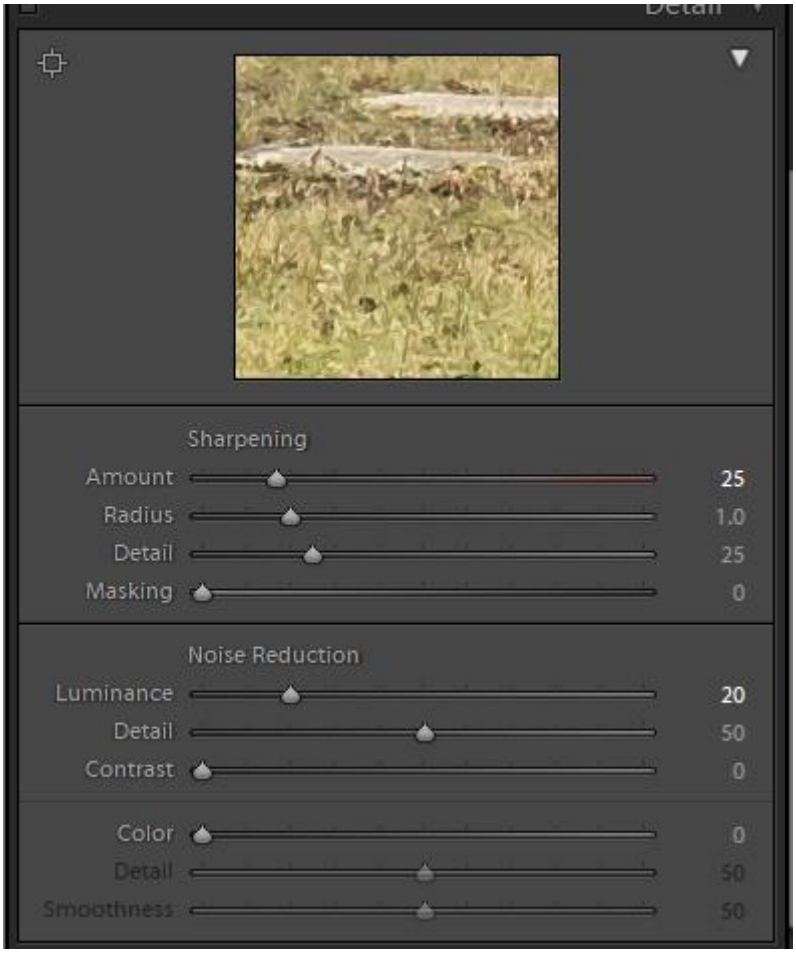


b.Clarity correction

d. Go to clarity and spice it up a bit (+5) help features pop a bit more

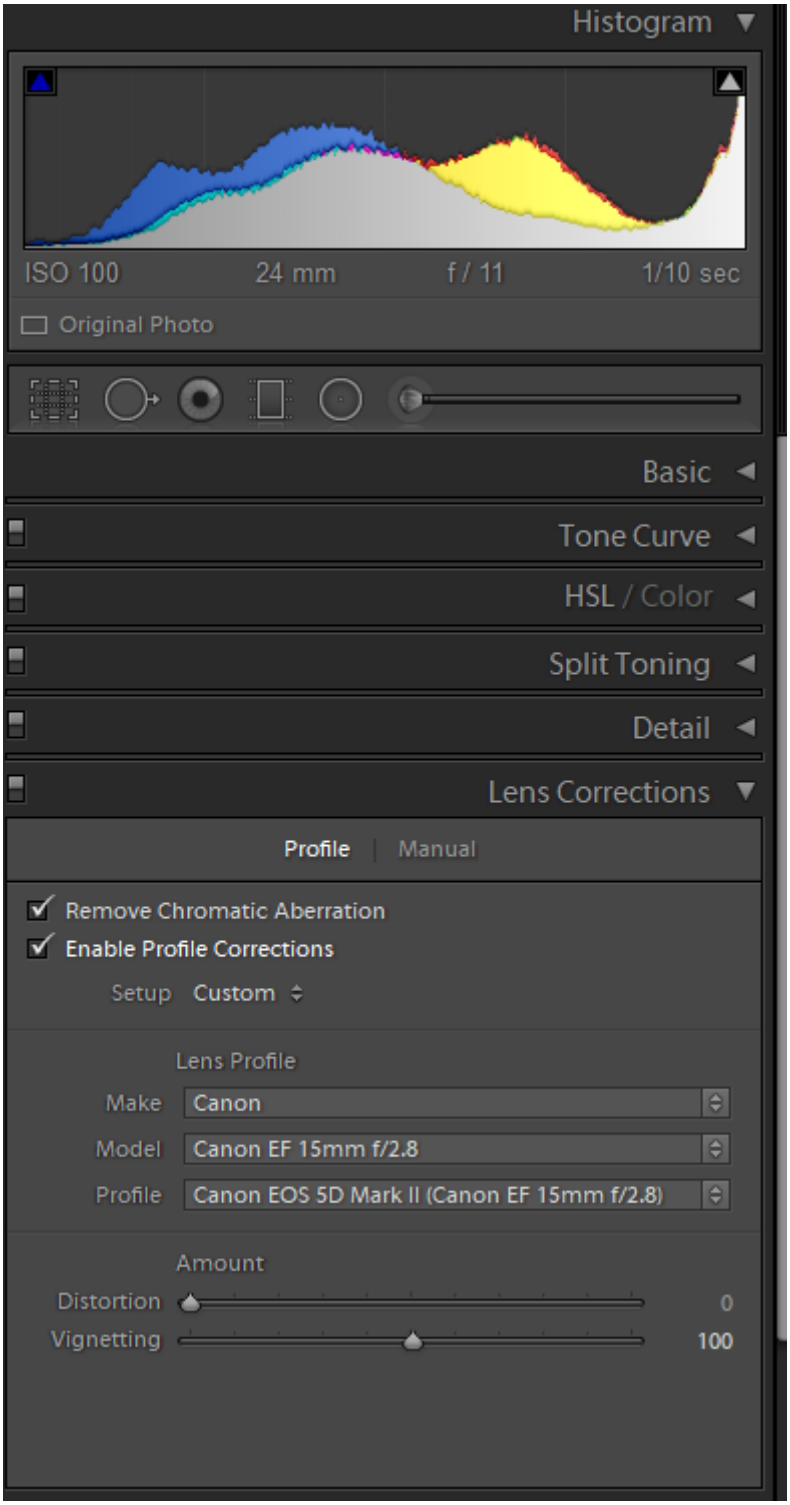
c.Noise correction in low luminescence images

e. Go to detail tab
f. Volume up just a small amount the sharpening (i.e from 25 to 35), making noise a bit more noticeable
g. Add luminance under noise reduction (i.e from 0 to 20-35) helps reduce noise



d.Lens correction

h. Remove chromatic aberration (remove artefacts from the lens)
i. Enable profile correction (removes vignetting)
    i. Choose appropriate profile/camera lens
    ii. Do not change vignetting level
    iii. DO NOT APPLY DISTORTION CORRECTIONS, reality capture will figure distortion corrections based on lens data (EXIF data), set distortion correction to 0


Histogram
ISO 100
24 mm
f / 11
1/10 sec
Original Photo
Basic
Tone Curve
HSL / Color
Split Toning
Detail
Lens Corrections
Profile
Manual
Remove Chromatic Aberration
Enable Profile Corrections
Setup
Custom
Lens Profile
Make
Canon
Model
Canon EF 15mm f/2.8
Profile
Canon EOS 5D Mark II (Canon EF 15mm f/2.8)
Amount
Distortion
0
Vignetting
100

e.Rule of thumb[22]

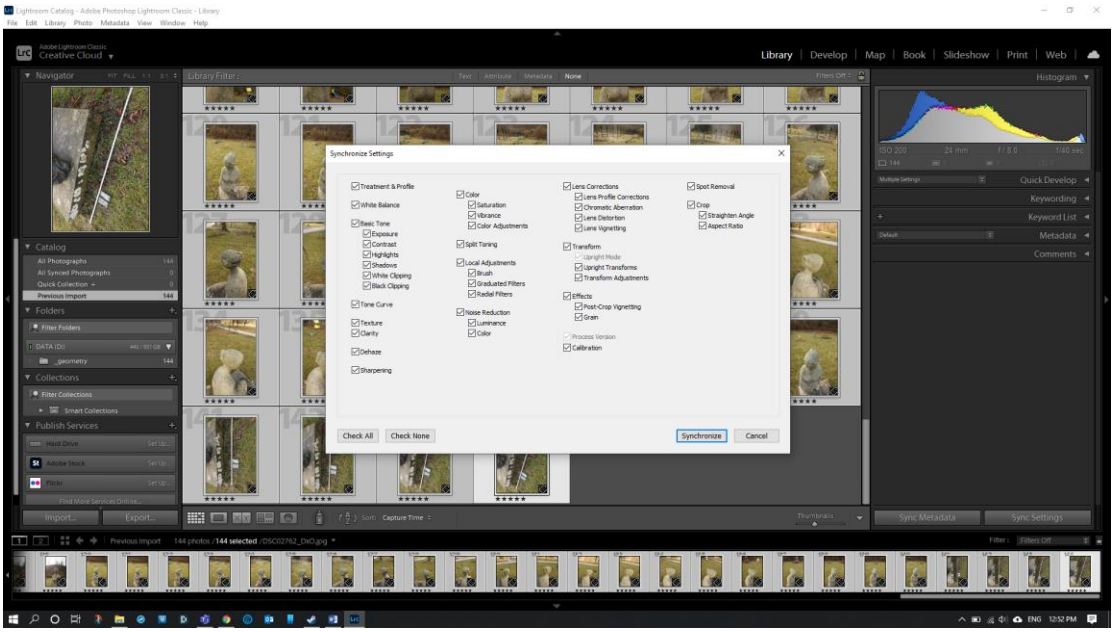
For most outdoors scans these are some recommendations:

- Exposure: from +0.0 to +1.5 (depends on the lighting condition. Usually, images are a bit underexposed)
- Lights: from -50 to -100
- Shadows: from +50 to +100
- Lights: from -50 to -100
- Blacks: from +20 to +100

You can add more micro contrast with Clarity, Vibrance, and Dehaze… For good low ISO images, the default denoise and sharpen is enough. But "Details" setting is better to set to zero.

f.Synch options to all photos

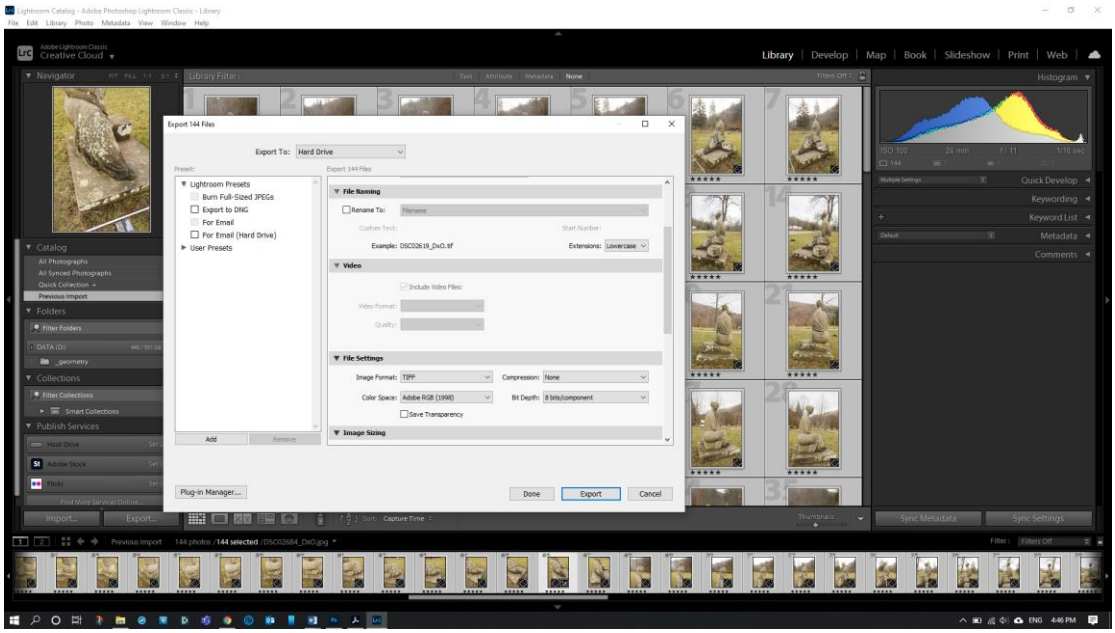
j. Go to image gallery
k. The selected image is highlighted and has a mark at the bottom right corner (edited)
l. Select everything and highlight edited image
m. Go to synch settings and check all options that we edited (white balance, color, lens corrections etc). DO NOT CHECK LENS DISTORTION



g.Export images

The basic idea of preprocessing is to increase the visibility of details in the shadows and light and increase micro contrast. Export in high quality jpeg format, or in 8bit Tiff format. For extra fine texture quality, you can create a separate folder with 16-bit depth tiff, but will be considerably time consuming in the texturing phase. 16bit images are only applicable during the texturing phase, in alignment and meshing Reality Capture will either use or convert 16bit to 8 bit.

[22] https://80.lv/articles/full-photogrammetry-guide-for-3d-artists/



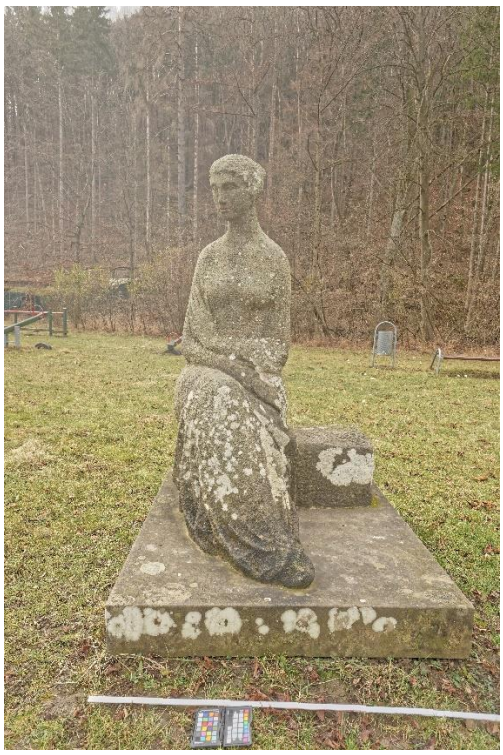
h.Quick tip- Image Layers[23]

When time is not an issue, it is usually a good practice to differentiate images into two folders named appropriately according to their usage:

- _geometry, will be used for the creation of the mesh, with original lighting and contrast and minimal editing in preprocessing programs, and with target points visible
- _texture01 will be used for the creation of the albedo maps and the texturing process of the model. As a rule of thumb, in order to create realistic lighting in later stage in a game engine such as Unity, we usually need defused images from the geometry folder with blunt colors in order to be used for texturing. The idea is that there are no big contrast differences due to physical lighting during the photo shooting process, in order for the game engine to create proper lighting scenarios based on a blunt texture with relative lighting values overall. Also, it is advised that in the textured version we remove all markers and targets and only leave any in case they do not create visual discomforts. Reality capture will use target points and reference points between the two photosets even if they are slightly different to insure proper alignment of both.

[23] https://www.youtube.com/watch?v=Xo-aBFMv_OQ&feature=emb_title

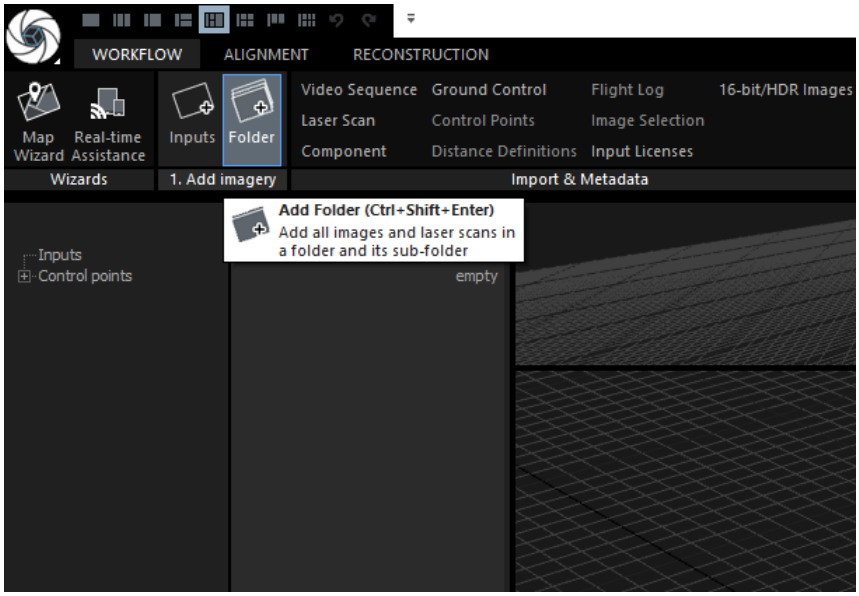
In general, the texturing photographs are a blunter version of the geometry ones. On the left we have the geometry version, on the right we have the texture version.



- Shift between image layers by pressing tab or shift+tab
- Rename folder appropriately (easier method)
- _geometry is for alignment and meshing
- _texture01 is for diffused texture usual flat lighting
- _texture02 is for diffused with delight techniques (copy pasted from geometry)
- All photos inside the folder MUST have the same names
- Drag and drop appropriately named folders in reality capture
- Check also paragraph importing 16bit/HDR photos

3.4 Processing in Reality Capture

a. Importing photos



On the workflow tab, press add imagery_ folder

b. Importing 16bit/HDR photos

When importing 16bit photos reality capture while give you the option to use original or convert to 8bit file format. Depending on the performance of the pc, the size of the database decides. If you convert, reality capture, will use the 8bit version for geometry and meshing and the 16bit for texturing, creating layers automatically. Otherwise, export from lightroom an 8bit tiff for the folder _geometry and a 16bit tiff for _texturing.

Tip!

In general asset creation such as buildings and sites, this is a time-consuming process both in preparation and processing and computational power. Therefore, it is advised to use typical high-quality jpeg or 8 bit tiffs and import them by the standard way of reality capture

c. Application settings

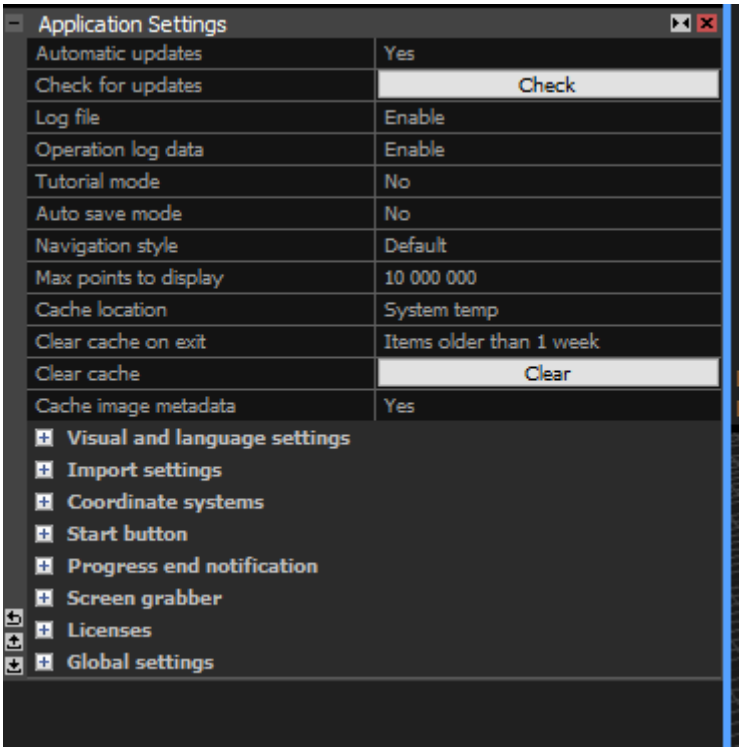
On the workflow tab on the top right go into application settings in order to set cache location

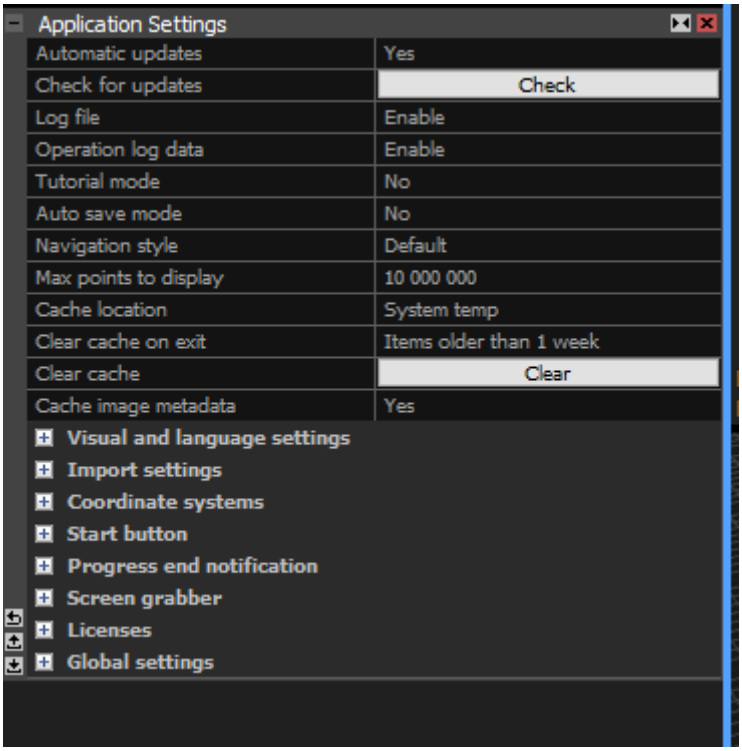
By default, RC uses a system Temp folder for all temporary files (that can range from 120-150Gb for an average 12-24Mpx image dataset). As soon as the files get used in the project, or you work with more than one project at the same time, it is better to set a Cache location to a dedicated big SSD (512Gb or more) or on a fast HDD.

RC runs 90% or all operations out of the core, and all temporary files are written to the Cache directory. These temporary files can be reused by Reality Capture in later steps and can drastically speed up calculations.

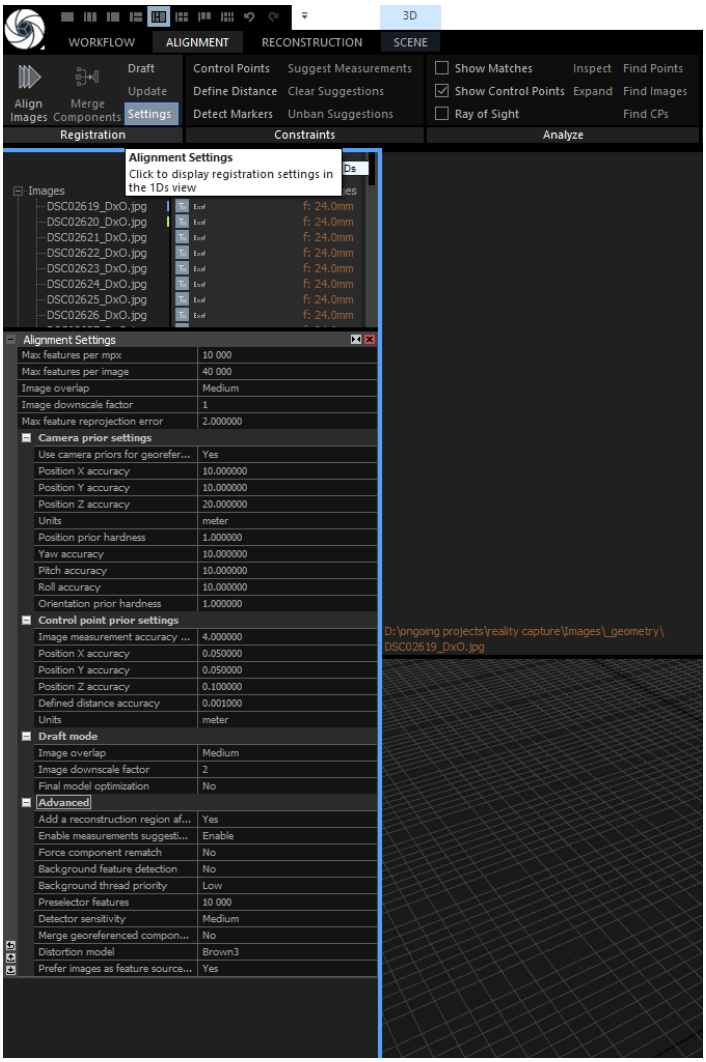
My recommendation is to set a cache location to another drive, for example, Z:/RC_TEMP. After this, RC will need to be reloaded.[24]

[24] https://80.lv/articles/full-photogrammetry-guide-for-3d-artists/


Application Settings
Automatic updates
Yes
Check for updates
Check
Log file
Enable
Operation log data
Enable
Tutorial mode
No
Auto save mode
No
Navigation style
Default
Max points to display
10 000 000
Cache location
System temp
Clear cache on exit
Items older than 1 week
Clear cache
Clear
Cache image metadata
Yes
Visual and language settings
Import settings
Coordinate systems
Start button
Progress end notification
Screen grabber
Licenses
Global settings


Application Settings
Automatic updates
Yes
Check for updates
Check
Log file
Enable
Operation log data
Enable
Tutorial mode
No
Auto save mode
No
Navigation style
Default
Max points to display
10 000 000
Cache location
System temp
Clear cache on exit
Items older than 1 week
Clear cache
Clear
Cache image metadata
Yes
Visual and language settings
Import settings
Coordinate systems
Start button
Progress end notification
Screen grabber
Licenses
Global settings

d. Setting general alignment settings



On the alignment tab, press settings.

Some key settings that affect the quality of the reconstruction process are:

- Max features per mpx Here you can specify the maximum number of feature points (per megapixel) for the natural feature detector in the alignment. More features mean lower speed but may result in fewer components.
- Max features per image defines the absolute limit to features used per image.
- Image overlap defines how much of the image space is covered with the same part of the object, when talking about neighboring images. Set Low when image overlap is below 20%. For the best quality, the neighboring images should have overlap greater than 60%. Bigger overlap improves speed while a smaller overlap may cause disconnected components if there are not enough photographs. Medium overlap can be set if all the images in the dataset have at least 70-80% overlap with the nearest images.
- Under Camera prior settings
    - Units, the units of the coordinate system in which the camera's priors and their accuracies are displayed

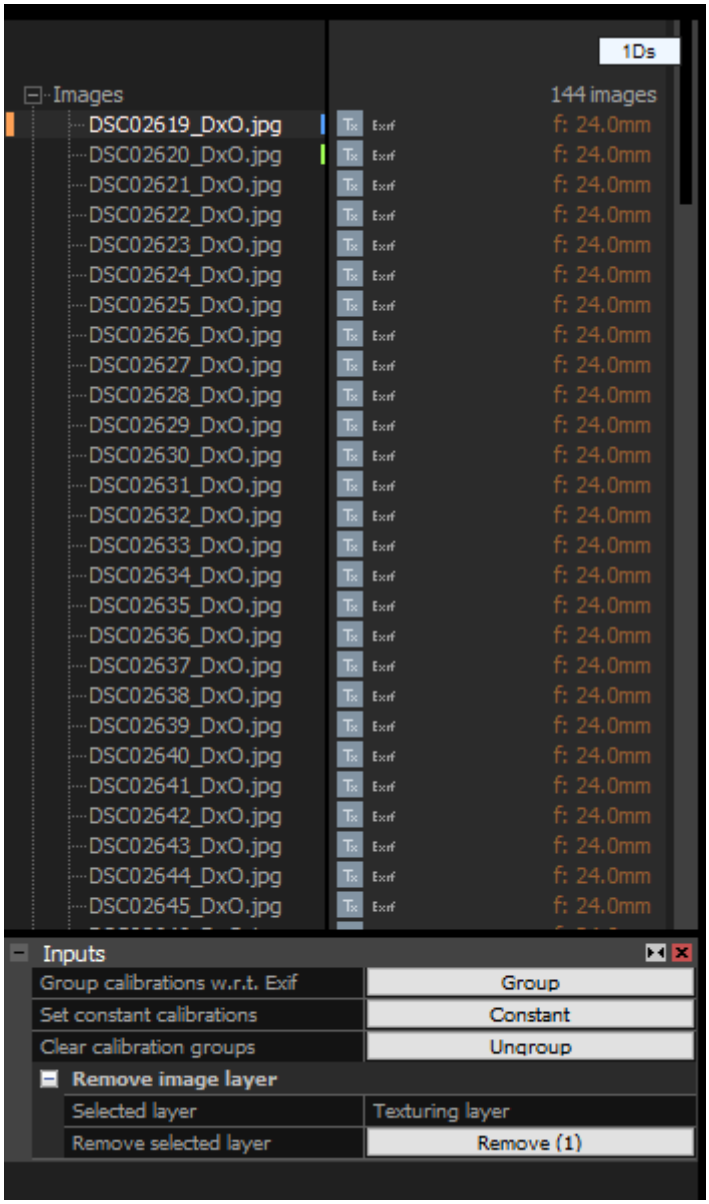
- Under advanced tab:
    - Force component rematch When set to True, the application will re-align images/cameras among each other in order to find better connections. It uses a camera pose to find new matches. Background detection (couple of points that are not clear and far, will try to use them)
    - Background feature detection Choose whether you want the system to automatically detect feature points in the background with a low priority of the processor. This can be useful, for example, when you want to place control points. Your computer will pre-process images and, in turn, save your time.
    - Background thread priority is a priority of the background detection. You have the possibility to choose from low and normal
    - Preselector features This is the number of features that will be used in alignment from the detected ones. Optimally, set it to 1/4-1/2 of the detected features.
    - Detector sensitivity low / medium / high / ultra. The natural feature detector focuses on places in an image which can be easily noticed and tend to be stable under various image and geometry transformations - e.g. changing the view point or changing lighting conditions. With this setting you can control how the detector looks at the stability. Setting it to ultra will detect more feature points in places with weak texture. This will also add points, which might have texture due to noise in the image. Setting this value to low will, on the other hand, throw away feature points which could be used for image registration. Detector sensitivity depends on aperture width when shooting, low for wider aperture (i.e 5.6 because focal point is mainly in the center, ultra relates to allowance of the software to use more points to edge where usually there are out of focus, as we have used a tripod and low iso we can go with ultra, thus capture all detail). Basically, it defines how fine and how many features (unique spots of the object) RC will try to detect. Example: for rich granite texture, you can use Low sensitivity. For subtle white marble texture, you will have to use High sensitivity.

    - merged components only set to false
        - if I want to merge components together and not look upon scan data or cameras set to yes

3.5 Starting the alignment process

a.Camera grouping by EXIF

Grouping can help you avoid the wrong camera and lens estimation. Reality Capture calculates these parameters from all images in one lens group. It is strongly recommended, for “one camera with prime lens” setups and turntable scans. In multi camera rigs grouping is not necessary.



Select images drop down list in the 1D tab and the inputs menu will appear, in case of older project press first ungroup and then group in order to create calibration groups.

b.Image overlap and detector sensitivity

After we have grouped images by EXIF data, change image overlap accordingly (if not sure set to low) and check required detector sensitivity and proceed to aligning.

c. Scaling the scene

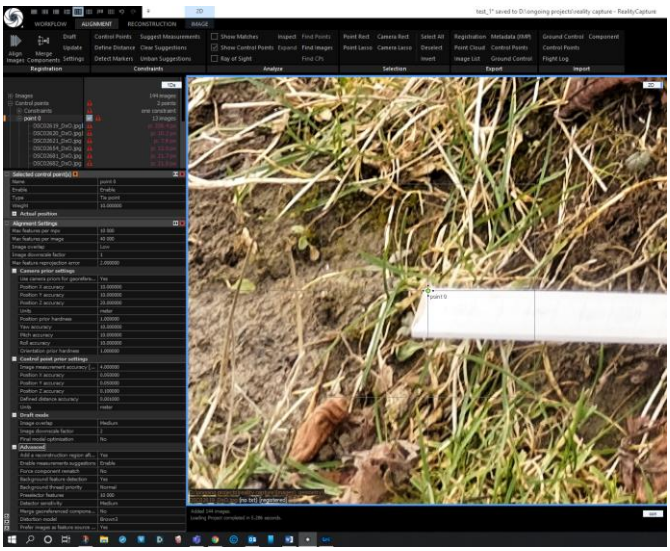
In general, there is a problem to determine the scale of a scene with photogrammetry methods. Some other prior information must be provided. In fact, just a single number is needed to scale the scene properly. In RealityCapture you have the possibility to scale your 3D model uniformly in all directions at the same time. Non-uniform scaling with a separate factor for each axis direction is not allowed. There are few ways to scale the scene.

i. Distance constraint

The simplest way to scale a scene is using the distance constraint tool. This tool is accessible in ALIGNMENT tab / Define Distance (F4). Using this tool, you can define distance between two control points in an interactive way. Please note that these two control points must be assigned to two or more images each.

Place at least two control points prior to adding the distance constraint.

- Activate the tool.
- Select an image in the 2D image view which contains control points between which you want to define a distance. Alternatively, select a layout with two or more 2D image views and select more images so that you can see both end points.
- Click and hold the left mouse button on any of the two end points.
- Move mouse cursor to the second control point (in any view). You will see a dotted line starting in the first point and ending at the mouse cursor pointer. The dashed line end will automatically snap near the control points and the application will automatically highlight them.
- Release the mouse button to confirm the creation.



This procedure will create a distance constraint between two points. However, you have not defined a physical distance between two end points yet. To do so, you need to set the distance in the panel which was opened right after you created the constraint. The constraint is not used in optimization before you define a distance by setting a non-zero value to the Distance property. If you disable the constraint, it can still serve as a ruler. Add more distance constraints to get more accurate results.

You can edit constraint properties in the 1Ds view under Control points' tree node.

ii. Direct Distance Constraint Definition

An alternative to the interactive way is the direct creation of a distance constraint in the 1Ds view under the Control points' tree.

- Place at least two control points prior to adding the distance constraint.
- Expand Control points' tree node in the 1Ds view.
- Click Create distance to create an empty constraint.
- A panel with the constraint properties will be opened automatically.
- Define a distance.
- Enter two end point names to the A and B fields.

Press update to update the alignment.

d. Aligning images

On the alignment panel press align.

e. Post alignment processing and debugging

If we have shot the dataset correctly 99% or all of the images align in the first step. And only lose a couple of images due to some problem with images. Bad images are most likely the ones with smaller than usual detected features that we have seen in the console view (click and hold on top of a panel and instead of 1d,2d,3d etc select con).

If we see in left window more than one component but our dataset was good, then RealityCapture can align all images as one component in the next step. We will need to delete the small components, leaving only the biggest and run align again.

At that point, RC will reuse the features detected in the first step (from data stored in the cache directory), refine the main component camera placement, and find a proper place for cameras from other components we had in the first align step.

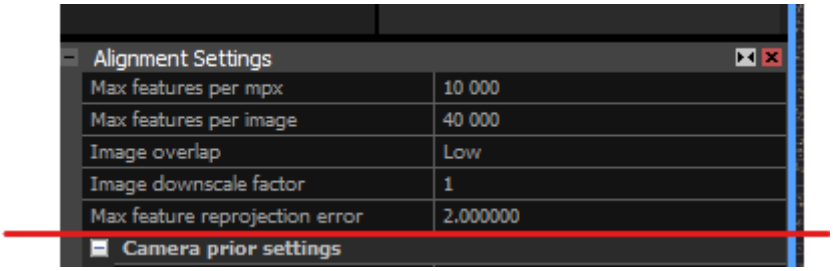
If necessary, this can be repeated several times. Even for one component, Reality Capture will refine camera orientation and lens settings, that can increase quality.

If every time after alignment, you see the same count of separate components with the same image count, this means that we'll need to use the manual control points. A tutorial on how to manually align and place control points can be found in this link: (https://www.youtube.com/watch?v=3ojj3q4S2o4).

f. Refine camera alignment- minimizing re-projection error

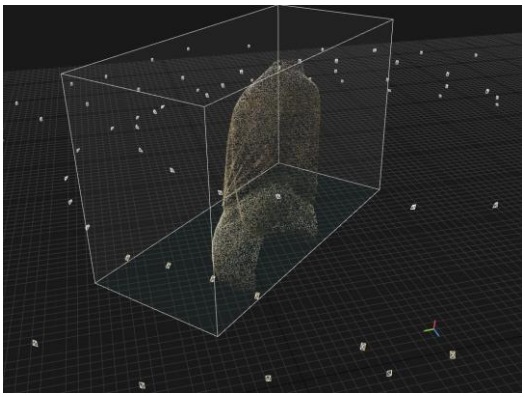
If we have photographed our asset properly and followed the process correctly, we should have one component with most of our photos properly aligned. As a final step, we can refine camera alignment. In order to do this, we can ungroup all images and run final alignment. During this process Reality capture will count all the cameras as different lenses and adjust the small deviations from the different zooms or sensors/lens shift from optical stabilization (if you used it).

During this step, we can decrease the minimal re-projection error. By default, it is at 2px. By setting it to 1px, will give a more precise alignment in the mean and median errors, minimizing the need for post processing, as we will have a better mesh quality.



g. Using the clipping box to select specific parts or points of the model.

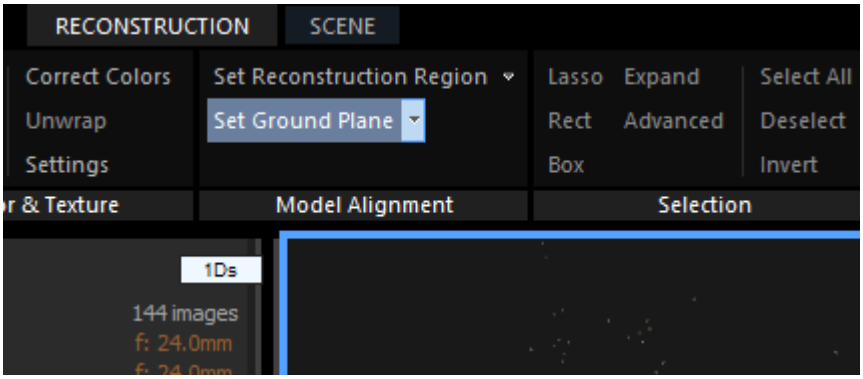
By using the reconstruction region, enclose only the parts of the model you want only to focus on. Then with the bounding box selected, go to the scene tab and on the tools, section select clipping box, create from reconstruction region.



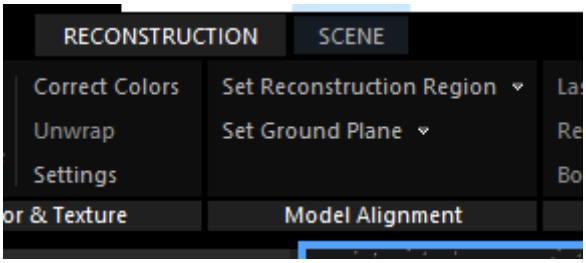
3.6 Starting the reconstruction process

a. Defining ground plane

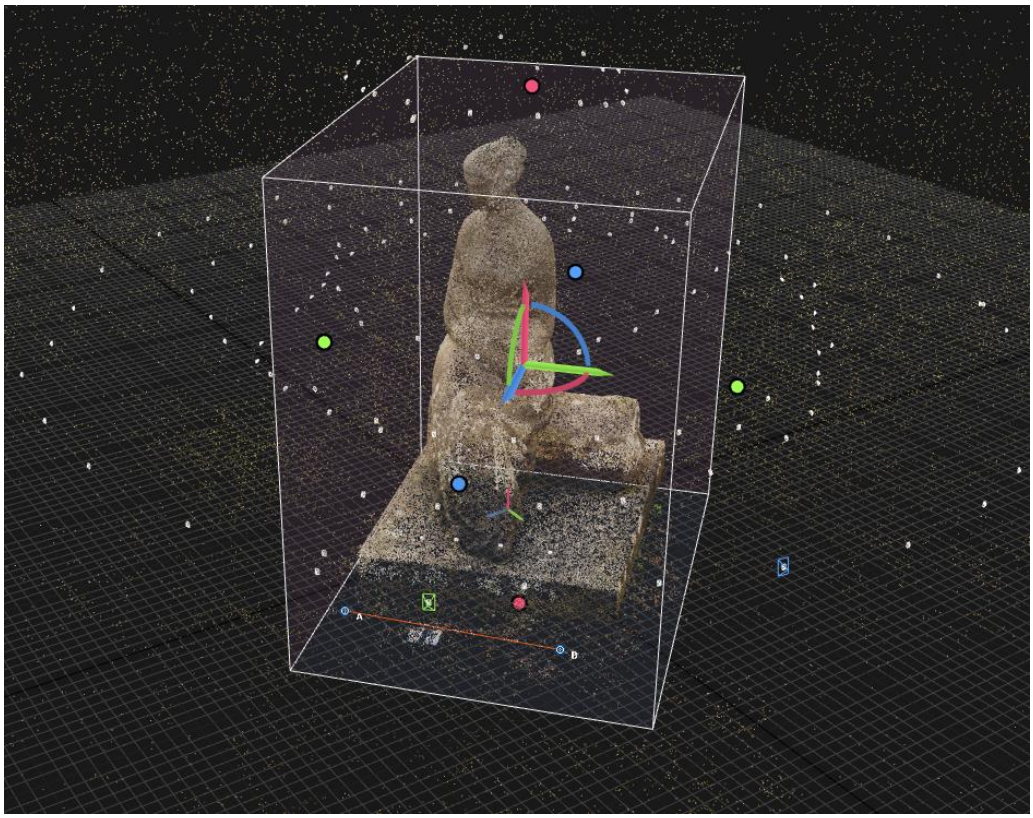
Before proceeding to meshing we need to define a ground plane. Switching between views can be done by the 4, 6, 2 num keys or by the scene tab. To define ground plane press



b. Setting reconstruction region

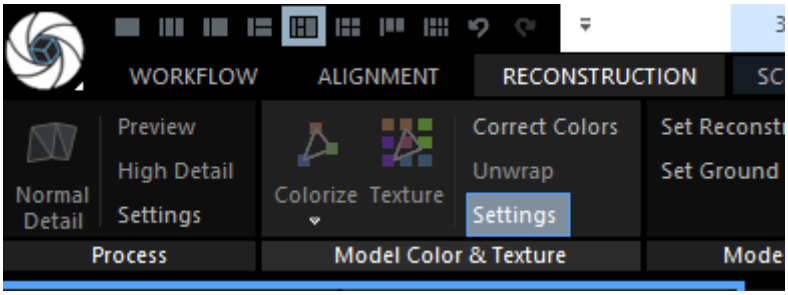


In Reconstruction Tab, click on set reconstruction region, select on the main viewport in 3d mode the appeared box and manipulate it accordingly in order to fit inside the model leaving out unnecessary spaces.



c. Meshing

In the reconstruction tab, click on normal detail or high detail based on your machine's capacity.



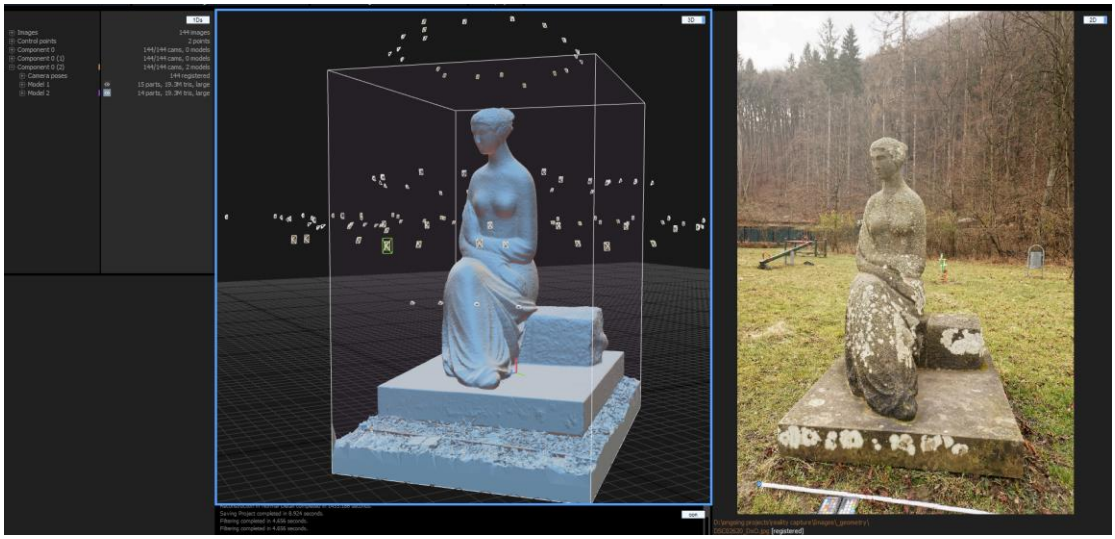
If you have default settings in Normal details mode, RC will calculate the depth maps from 2x downsampled images. The High details mode uses images without downsampling. RealityCapture can reconstruct details up to 0.25px, meaning that meshing in Normal mode sometimes is enough.

If you are sure that dataset is clean and sharp, by meshing in High Detail mode you will get more real details. However, this can take more time.

For a test, we can set 4x down-sample for Normal details mode. This will give enough details to estimate the final mesh quality in High Detail and will be finished pretty fast (20-30 minutes for 5-10mln poly mesh on decent hardware).

At this point before starting and after completing the meshing project it is good to save your project.

The result should look something like this



d. Simplification

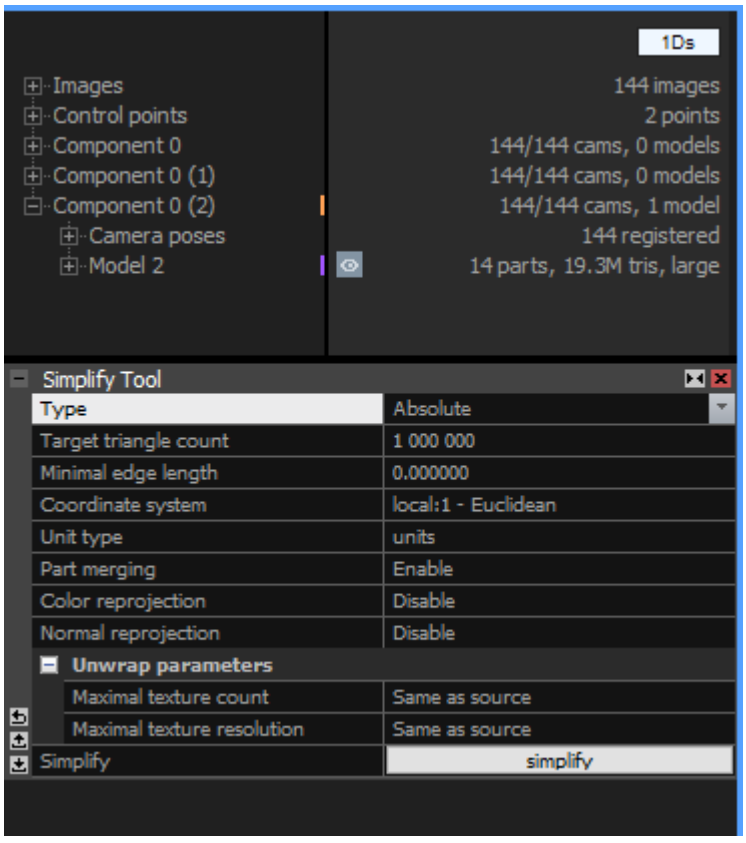
The common polygon count for a mesh reconstruction in high resolution is about 100-200 mil polygons.

i. Simplification strategies

4k textures can store micro details in a normal map from about 16mln polygons, 8k can go about 67mln polygons maximum. To get the best results 16mil poly mesh details need to be stored on 8k normal map.

We can simplify a raw 100-200mil poly mesh to 8-16mil poly without any issues. The decimation algorithm will preserve the sharp details.

It is best practice at this point to create two separate meshes that will be used of different tasks. To that end we will keep the original high polygon model (over 30mill faces) and create also a second model that will be used for texturing (around the area of 20-30 mil faces)



The simplification tool is located in the reconstruction panel and it opens up the above window. On the type, you can select either Absolute or relative.

- Absolute is used if we want a specific number of polygons
- Relative uses percentages to simplify.

In either case, aggressive simplification will lead to topology defects and will ruin the geometry. It is best practice to simplify in small increments usually increments of 60% of the original is a good reduction.

e. Texturing and coloring

When you have already created a model, you are now able to proceed with adding colors to it, which can be done either by using a Colorize or Texture function. It is important to understand the difference between the two of them. Coloring creates only colors for model vertices, which is fine for denser objects, and which makes the model smaller in size, compared to a textured model. Simply speaking, texturing creates a small image for each triangle of the model. It actually creates one or more images called textures and defines mapping among them and triangles. This mapping is called unwrap. This method is therefore more realistic than coloring.

i. Best practice in texturing/ coloring selection

The selection of what method to use is based on the intended output result. If the intended result is a dense point cloud with color and not a textured mesh, we can use the coloring mode and export as a typical ply file format, which is a dense point cloud format. Point cloud file format are good for reference and to have a quick overview of the site/asset in question, but they are not editable geometry and can be viewed and partially edited with meshlab.

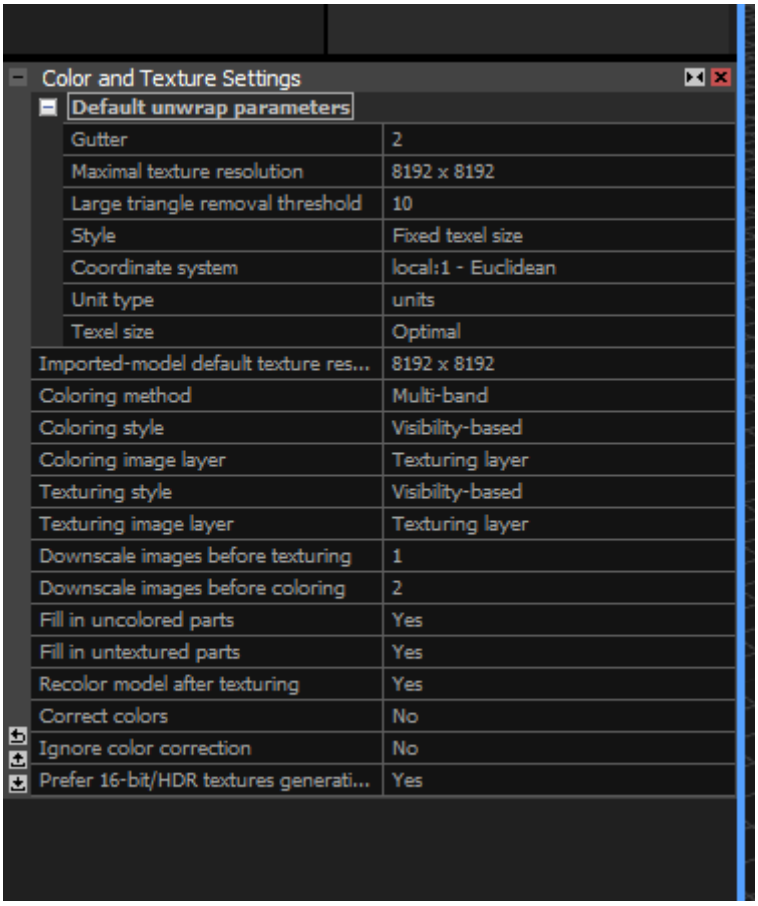
Otherwise, we will use the texturing option that will produce a textured mesh, which is a geometry file format that you can edit and reshape accordingly such as Maya, Blender etc.

ii. Texturing strategies

Generally, of objects that are 2-3 meters in height or larger, it is good to generate a 16k texture resolution that will later be reduced to a final 4k or 8k texture

iii. Texturing settings

Before processing the texture- or the albedo map, we need to set some specific settings in settings.



Go to the reconstruction tab and select settings on model color and texture box and the settings box will appear in the 1D panel.

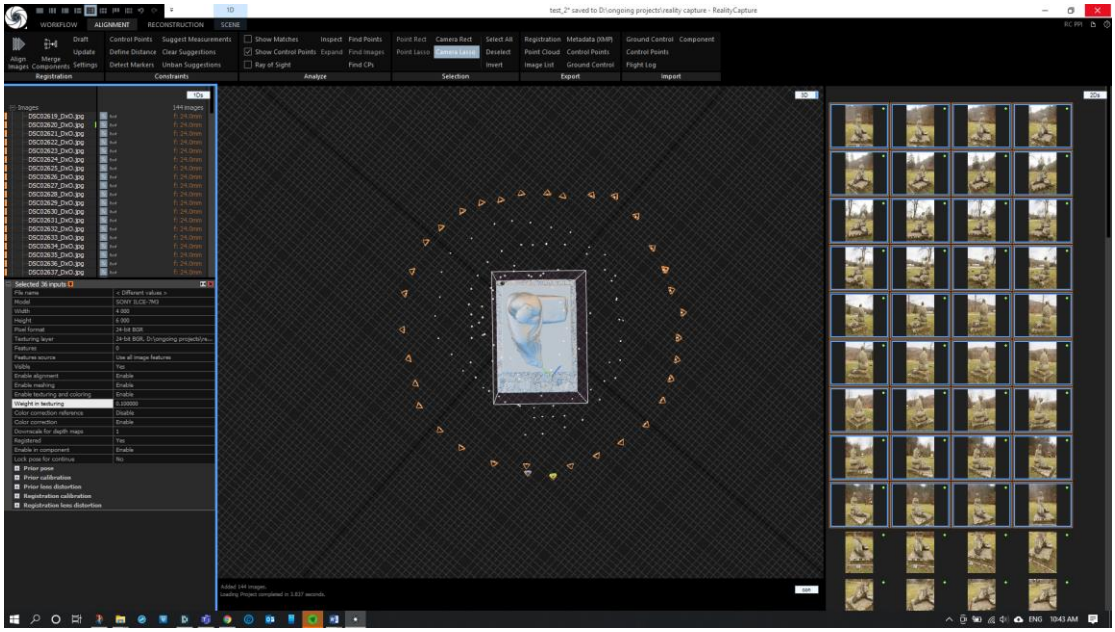
- Large triangle removal threshold- any area with triangle count smaller that the <value> will not be textured, they will not register a value in the uv mapping process. This means that even big triangle holes, will have their own space in uv coordinates and thus will be textured appropriately.
- Maximal texture resolution- set to appropriate resolutions usually 8k or 16k
- Style:
    - Maximal textures count: the texel detail is adjusted automatically so that the texturing fits into the selected maximal number of textures within the selected maximal resolution
    - Fixed texel size: a good approach if your intention is to deliver a model with pre- defined visual precision (e.g. 1cm resolution for creating a true ortho-photo map). In this mode, there will be so man textures how many are needed to texture the model with the selected texel size. As a best practice, we recommend using fixed texel size provided we have a good image sample and overlap of images. As a result, all the pixels and triangles are going to have the same pixel size. This will account for various mesh resolutions due to distance of the captured photos and the object. The end effect will be a texture that has the same resolution everywhere. This is something that is required in VR, in order to have a realistic effect.
    - Texel size set to optimal, will be set automatically based to the optimal value or we can set dimensions of a texture image pixel. When using the custom option, set this value, for example to 0.01 to make a 1cm texel if the coordinate system unit is a meter. Once you have a model calculated, you can use the Unwrap tool to estimate the minimal reasonable resolution.
- Texturing layer: if we have used two layers in the photo shooting, geometry and texturing, we specify to the program to use the texturing layer

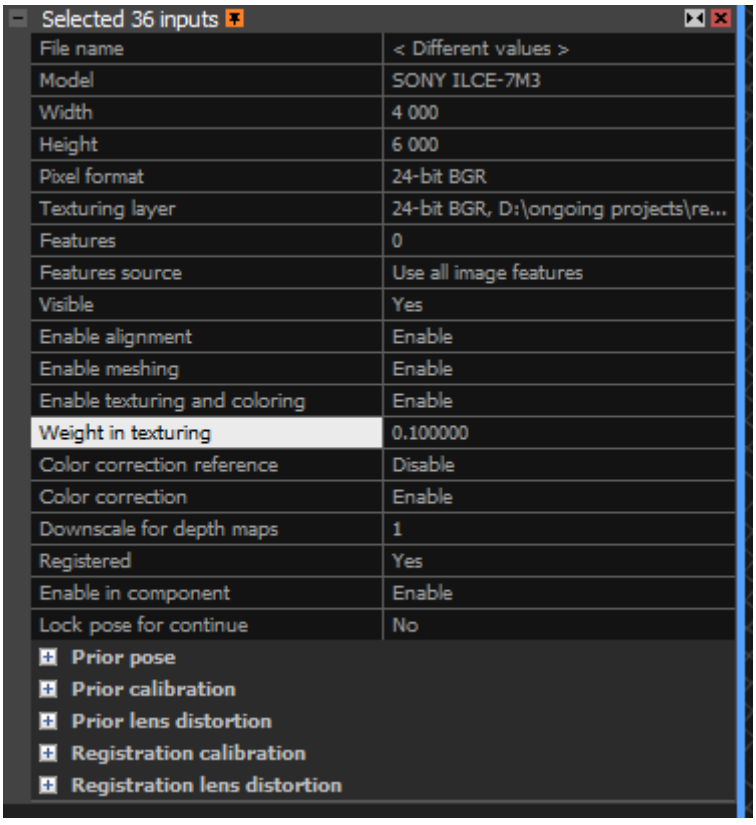
iv. Excluding images from texturing

As reviewed during the photo shooting techniques, in most cases and especially in models with difficult geometry, it is considered best practice to have a set of photos that capture the whole of the model in each of them from various angles, in order to facilitate the alignment process and to capture the overall geometry. However, while these images are useful for geometry, they could downgrade the quality of the texture due to distance from the model.

For improved texturing results, we need to change the weight in texturing for cameras from the outer loop to a really small value.

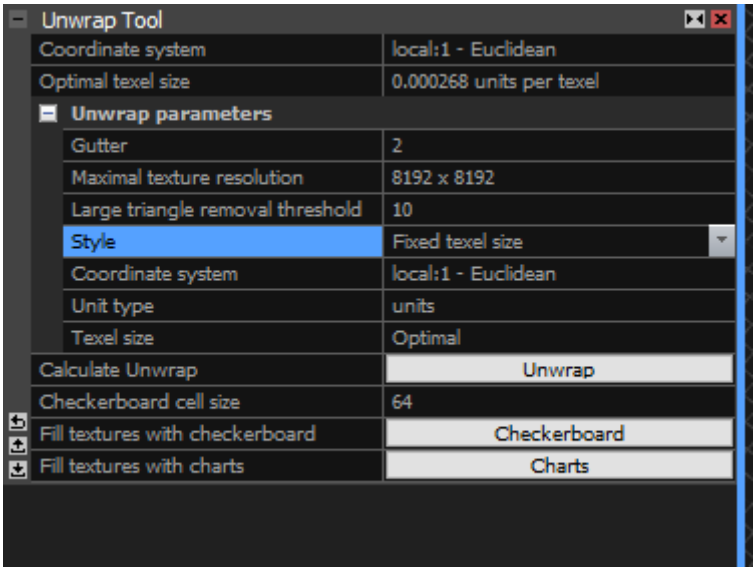
By using the camera lasso tool, select these outer cameras, or select all middle and close-range cameras and invert the selection. Change the weight to 0.01 (1%) or less of all selected cameras at once in image properties.




Selected 36 inputs
File name
< Different values >
Model
SONY ILCE-7M3
Width
4 000
Height
6 000
Pixel format
24-bit BGR
Texturing layer
24-bit BGR, D:\ongoing projects\re...
Features
0
Features source
Use all image features
Visible
Yes
Enable alignment
Enable
Enable meshing
Enable
Enable texturing and coloring
Enable
Weight in texturing
0.100000
Color correction reference
Disable
Color correction
Enable
Downscale for depth maps
1
Registered
Yes
Enable in component
Enable
Lock pose for continue
No
Prior pose
Prior calibration
Prior lens distortion
Registration calibration
Registration lens distortion

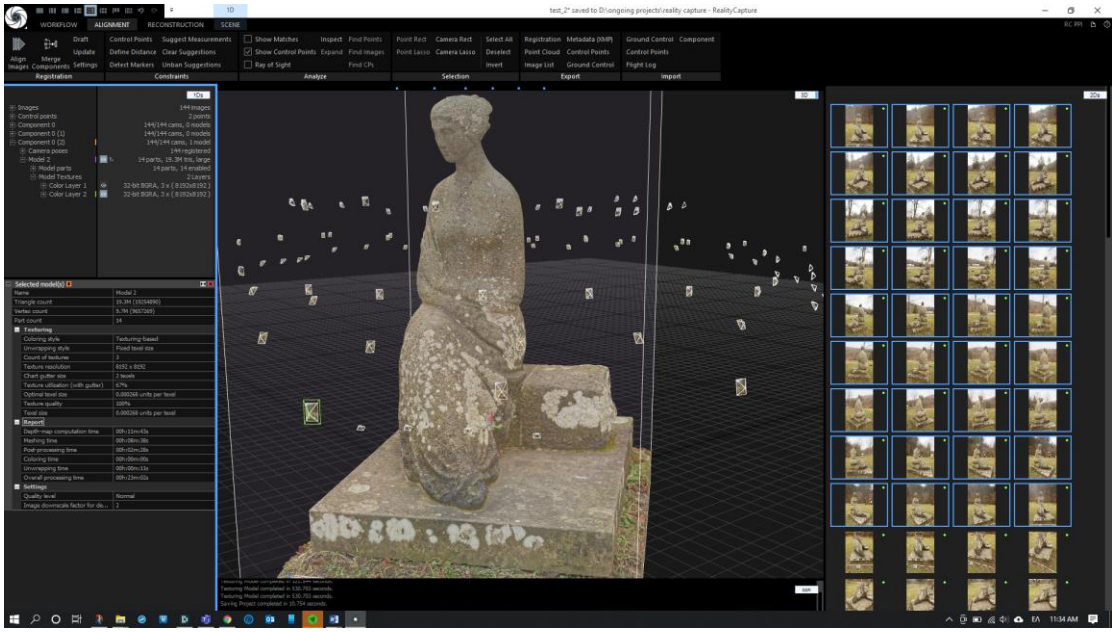
v. Uv unrwap

After all these setting have been applied we go to the reconstruction phase and press on the unwrap tool and press unwrap

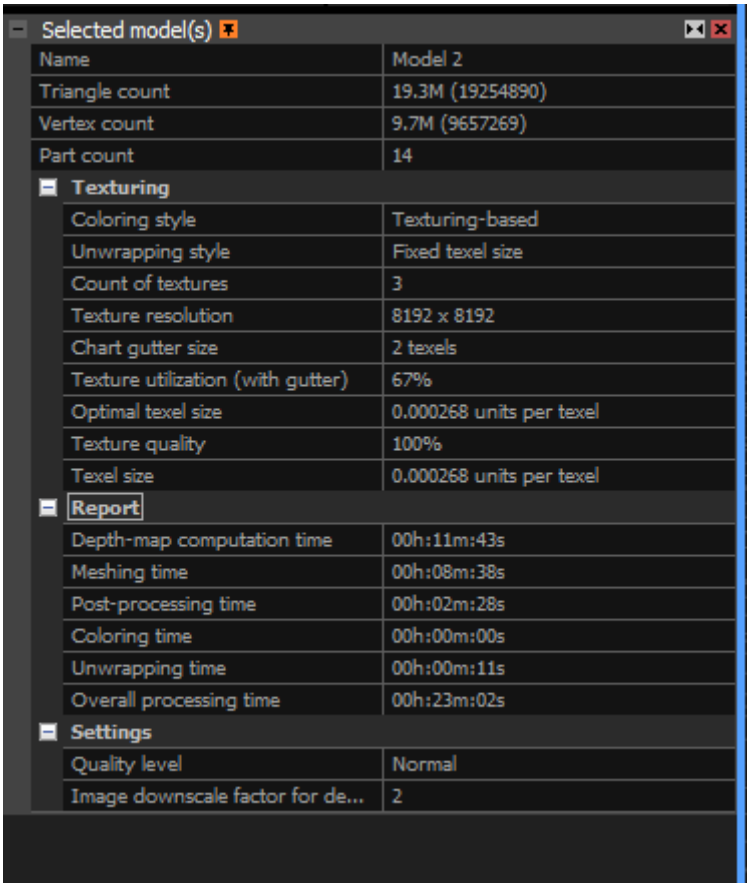


vi. Texturing

After the unwrap is finished we press texturing, at the end of the process we will have something that looks something like this



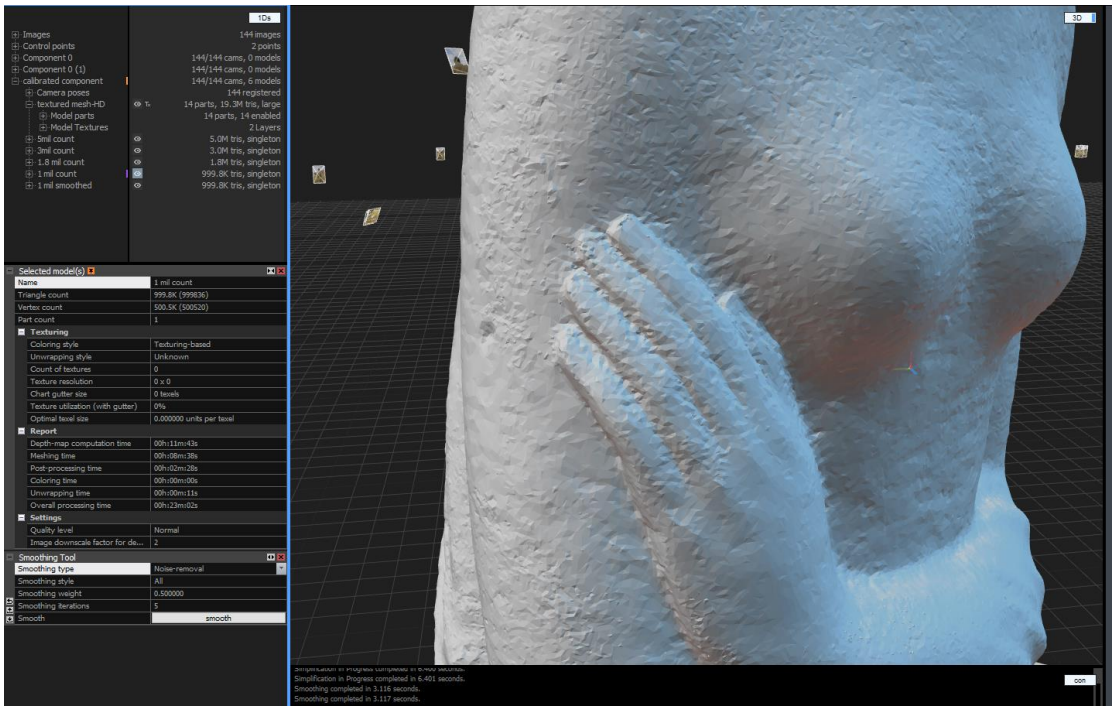
On the report we have some useful information that looks something like this with useful



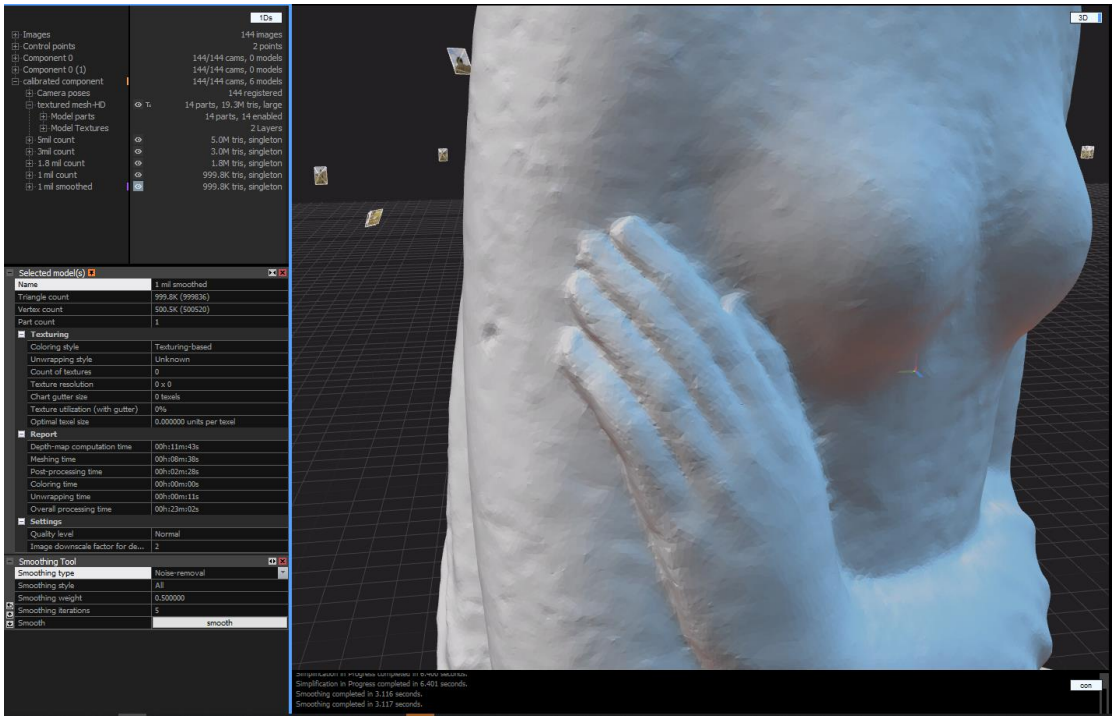
Most importantly, on texturing we are interested in texture utilization and texture quality, with texture utilization relating to the Percentage of used texels. Texture quality equals to the percentage of a texel size w.r.t. the optimal texel size. It says about how the texture is detailed w.r.t. the maximal detail that you can get from images.

f. Simplification before exports

Before proceeding to export the model and texture, we should use again the simplify tool to drop the mesh model to a mid-resolution mesh- around 5mil triangles and a low-resolution model that is easy to handle and upload in the range of 700.000 triangles to 1.5mil triangles.



In the above picture we have the quality of the mesh after simplifying to an amount of 1mil triangles.



In the above picture we have the same number of triangles but after applying a smooth operation

g. Retexturing and export

After the simplification process, unwrap again and retexture with appropriate texture settings. For use in an online repository or for nonscientific work such as a virtual exhibition, the use of a 4k texture size is more than enough.

Use the texture reprojection tool:

- Set source model to the high polygon model (textured)
- Set target model to low poly model
- Set super sampling up all the way to 64
- Enable color reprojection
- Enable displacement reprojection
- Enable normal reprojection

h. Export mesh models

On the project folder we will export all necessary elements and models with appropriate naming. High polygon model, low polygon model and export all related material by selecting the model we want to export and pressing in the reconstruction tab model export.